VOLUME LI NUMBERS 3 and 4

THE HAWAIIAN PLANTERS' RECORD

Aerial view of the Experiment Station, H.S.P.A.

THIRD AND FOURTH QUARTERS, 1947

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THE HAWAIIAN PLANTERS' RECORD

Vol. LI THIRD & FOURTH QUARTERS 1947 Nos. 3 & 4

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

A Suggested Critical Potash Level in Leaf-Punch Samples

By R. J. BORDEN

A critical concentration of potash which probably indicates a potash deficiency in the dry weight of leaf-punch samples from 32-8560 cane is suggested when less than 0.5% K20 is found at three months and this level drops below 0.4% K20 at four months.

It has been assumed that the per cent K20, in the leaf-punch samples of 32-8560 cane, which is associated with significant evidence of an increase in the total dry weights of stalks, tops, trash, and roots, secured from potash-fertilized over non-potash-fertilized cane, ought to provide us with a figure which represents a critical potash level, and that this measurement should be a useful guide for potash fertilization.

To check this assumption we have now completed three preliminary skirmish tests with results as follows:

I—A-105—No. 164

TOTAL DRY WEIGHT (GRAMS HARVESTED)

Soil[1]	Crop Age Months	Without K20	With K20	Response to Potash	% K20 in Leaves[3]
Makiki	4	249	240	None	.91
Makiki	6	573	603	Doubtful	.76
Mixed[2]	4	301	312	None	.76
Mixed	6	633	689	Doubtful	.60
Manoa	4	354	378	Doubtful	.57
Manoa	6	711	711	None	.45

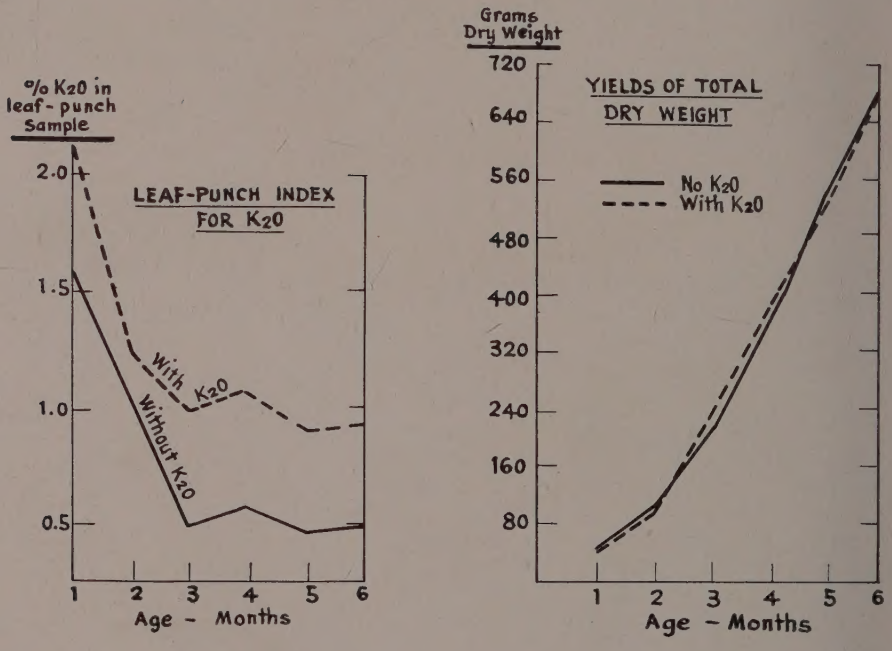
1—Soils diluted (1 to 1) with silica sand.
2—¼ Makiki + ¼ Manoa soil (+ ½ silica sand).
3—In dry weight of leaf-punch samples from cane which received no K20 fertilizer.

At the time of potting, the three non-potash-fertilized soils which were used had the following per cent K20 contents (by R. C. M.):

Makiki .011%; Makiki + Manoa Mix .007%; Manoa .004%.

This skirmish was only planned for a period of six months. During this period we did not secure a definite response to potash fertilization from any of the diluted soils that were used, even though the potash concentration in the leaves of cane on the Manoa soil had dropped to .45 per cent K20 (Fig. 1). This would seem to indicate that the critical level for K20 in leaf-punch samples from 32-8560 cane is somewhere below .45 per cent.

FIG. 1 – CROP ON MANOA SOIL



Incidently, the total amounts of potash found in the total dry weights at six months show a more complete recovery (of the 3.0 grams of K20 applied) from the Makiki soil than from either the Mixed or the Manoa soil. Since our cultural technique provided against any loss of nutrients by leaching, it would appear that some characteristic of the Manoa soil had held back and actually made unavailable some of the potash that was applied in the fertilizer.

GRAMS OF K20 RECOVERED IN ENTIRE CROP AT SIX MONTHS

Soil	Without K20	With K20	Difference	Unaccounted for
Makiki	1.547	4.281	2.734	.266 grams or 8.9%
Mixed	1.322	3.691	2.369	.631 grams or 21.0%
Manoa	1.048	3.174	2.126	.874 grams or 29.0%

II—The results from the second skirmish (A-105 — No. 183.1) were as follows:

TOTAL DRY WEIGHT (GRAMS)

Soil	Crop Age Months	Without K20	With K20	Response to Potash	% K20 in Leaves
Makiki	4	402	406	None	.69
Makiki	6	858	829	None	.66
Makiki	10	1515	1494	None	.56
Manoa	2	63	63	None	.78
Manoa	3	170	179	None	.44
Manoa	4	368	396	Favorable	.33
Hilo	2	57	57	None	.73
Hilo	3	168	181	Doubtful	.45
Hilo	4	302	330	Definite	.38
Kauai	2	48	48	None	.87
Kauai	3	114	141	Definite	.35

Analyses of these four soils before potting and fertilizing were as follows:

	SOIL			
	Makiki	Manoa	Hilo	Kauai
K20 by RCM	.032%	.007%	.007%	.003%
Replaceable K20*	.126%	.022%	.028%	.009%
Total K20 *	1.12%	0.84%	0.92%	1.68%
Per cent of Total K20 which is replaceable K20	11.25%	2.62%	3.04%	0.54%

* Analyses by Chemistry Department.

No favorable response to potash fertilization had been secured at ten months from the 32-8560 crop on the Makiki soil, although the per cent K20 in the leaf-punch samples had then dropped to .56 per cent.

On the Manoa soil a favorable response was not found until four months when the leaf-potash concentration was down to .33 per cent. At three months when the leaf samples contained .44 per cent K20, the total dry weight harvested from the cane which had not been fertilized with potash was not significantly less than the weight from the potash-fertilized cane.

The Hilo soil responded to potash when the potash level in the active leaves had dropped to .38 per cent; the response was of doubtful significance when the leaf samples showed as much as .45 per cent K20.

A response to potash was not found at two months on the Kauai soil when there was .87 per cent K20 in the leaf samples, but the potash fertilizer effect was definitely favorable a month later when the level in the leaves had dropped to .35 per cent.

III — The third skirmish (A-105 — No. 183.2) concerned with this objective is summarized as follows:

TOTAL DRY WEIGHT (GRAMS)

Soil	Crop Age Months	Without K20	With K20	Response to Potash	% K20 in Leaves
Makiki	2½	134	140	None	1.24
Makiki	4	396	382	None	.76
Makiki	6	822	803	None	.52
Manoa	2½	178	179	None	.28
Manoa	4	425	463	Definite	.26
Hakalau	2½	77	78	None	.52
Hakalau	4	262	322	Definite	.34
Kailua	2½	171	176	None	.38
Kailua	4	405	441	Definite	.33

Before potting, these soils showed the following per cent K20 by R. C. M.: Makiki* .025%; Manoa* .003%; Hakalau .004%; Kailua .004%.

The 32-8560 crop on the Makiki soil had shown no proof of a response to potash at six months, even though the K20 in the leaf samples had dropped to .52%.

Although a low value of only .28 per cent K20 was found in the leaves from the Manoa soil at two and a half months, this apparently did not indicate real potash deficiency. This is hard to understand in view of the fact that a value of .26 per cent in the leaves at four months was associated with a definite response to the potash fertilization.

A quite similar situation was found from the crop on the Kailua soil. Here too, although .38 per cent K20 at two and a half months appeared to be an adequate level of potash, a value of .33 per cent at four months was apparently inadequate to maintain yields comparable with the potash-fertilized plants.

The Hakalau soil showed a response to potash at four months when the leaves had .34 per cent K20 although this response had not been obtained at two and a half months when the leaves contained .52 per cent K20.

Close observations to identify the common leaf symptoms of potash deficiency were made in all three of these tests but no such symptoms were found. Hence it is possible that an actual potash shortage can be effective for a considerable length of time before visible symptoms are noted, and that the potash deficiency is an acute one when these leaf symptoms are actually seen.

If we can interpret the results from these studies correctly, we would like to set up a figure to indicate critical levels of potash for 32-8560 cane at the ages of three and four months, and so be in a position to use such guidance in time to correct a possible potash deficiency in the current crop by potash fertilization. The data we have collected leads us to suggest this guidance, temporarily (i.e., subject to further study and verification) as follows:

If the leaf-punch samples from 32-8560 cane taken at three months show less than 0.5 per cent K20 *and* if this figure drops below 0.4 per cent K20 at four months, apply potash fertilizer to the crop immediately in order to correct what we believe is a soil potash deficiency. Before general acceptance of this suggestion, it should be adequately checked in properly designed Grade A experiments on different soil types and under different climatic conditions.

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* These Makiki and Manoa soil samples were from the same localities but not from the identical sources as those used in the earlier studies.

Dedication Ceremonies of the Agricultural Engineering Institute, University of Hawaii September 5, 1947

Opening Remarks

By P. E. Spalding
Chairman of the Board of Regents

The purpose of this little meeting is primarily to dedicate a building and its equipment to the promotion of instruction and research in agricultural engineering in Hawaii, and secondarily to focus public attention upon the possibilities of cooperation in the education of young men for Hawaii's basic industries.

It has been suggested that I speak on the history of the Agricultural Engineering Institute. The history of the Institute is very brief but it is also of much interest to those of us who have been closely connected with it. I think it was first proposed in April of 1944. It was during that year that Professor H. B. Walker from the University of California was called in by the Hawaiian Sugar Planters' Association as a consultant in agricultural engineering. It had been apparent to the H.S.P.A. for some years, even before the war, that its agricultural operations required the development of machines to perform some of the services which were being performed by hand. The war accentuated the situation and machines designed for other purposes were adapted for various uses. Many of these were crude and awkward but they performed work which otherwise could not have been accomplished. As time went on it became apparent that these crude machines were not of temporary use but had become a fundamental part of operations. It therefore became necessary to study the actual operations and to endeavor to perfect designs of machines directly for the jobs to be performed.

As a result of Dr. Walker's visit, the H.S.P.A. and the Pineapple Research Institute each established agricultural engineering departments early in 1945. Mr. E. J. Stirniman was appointed to head up the sugar group and Dr. E. G. McKibben headed up the pineapple group. Both of these men were confronted immediately with the necessity for machine shops in which machines could be developed for experimental purposes.

Conversations were soon commenced with the University as to the need for young men to be instructed in the building and operation of agricultural machines. It was suggested in August of 1945 that cooperation of the three groups — University, Pineapples and Sugar — might produce quicker and better results than independent action. The University Regents, in the following October, endorsed the proposal "in principle". The University group, headed by Prof. Wadsworth, worked for many days with the sugar and pineapple groups in framing the charter of the Institute. Dr. Arthur L. Dean was extremely helpful in this work until finally a "writing" in form satisfactory to all was accomplished.

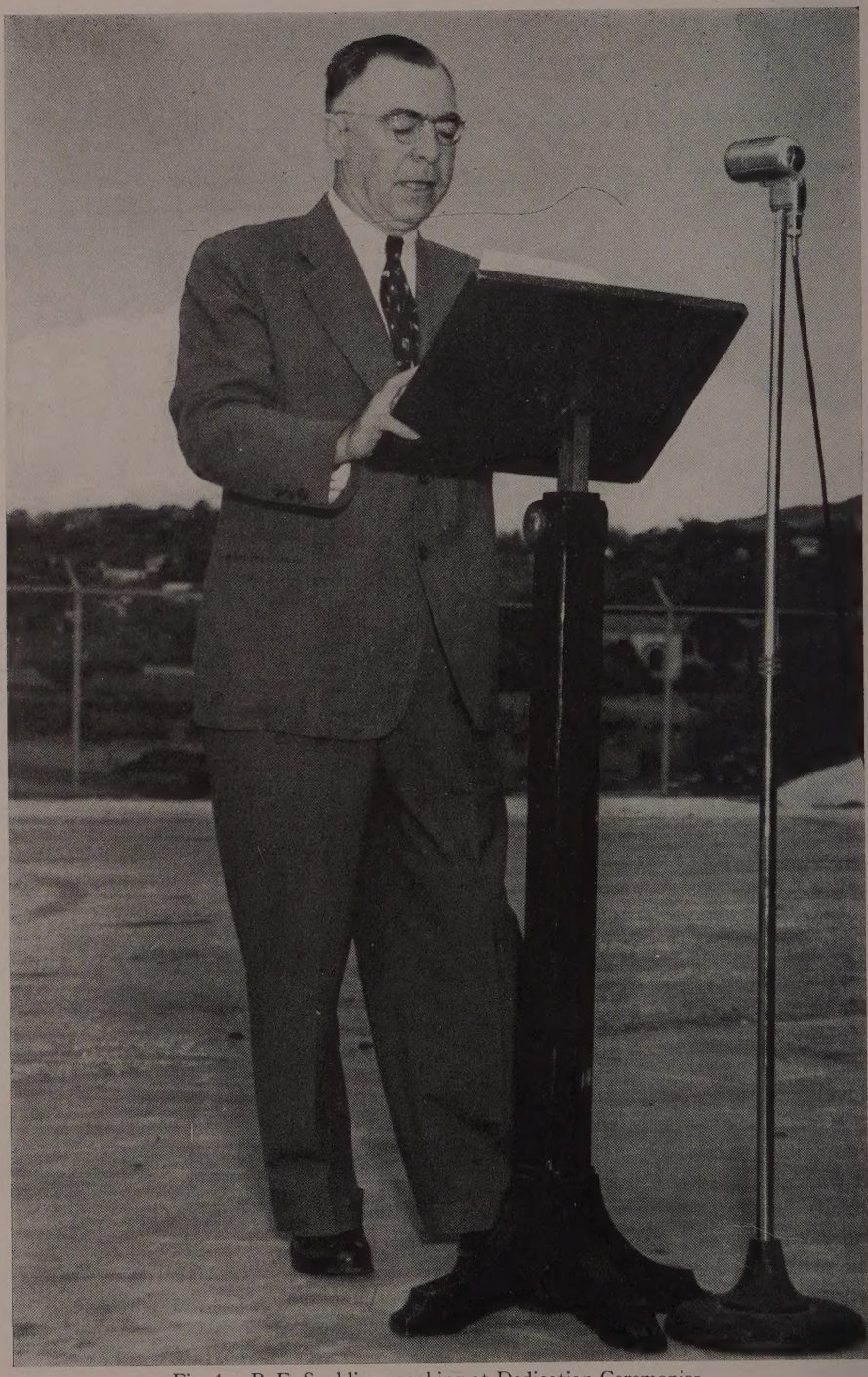

Fig. 1. P. E. Spalding speaking at Dedication Ceremonies.

Then in December, 1945 I had the pleasure and privilege of announcing a gift by the H.S.P.A. of $100 000.00 toward the building and equipping of the proposed institute. Mr. A. J Hebert then entered the picture as Chairman of the H.S.P.A. Engineering Committee. He took hold of the project with real enthusiasm; enlisted the services of Mr. T. A. Vierra, H.S.P.A. architect, and succeeded in securing unanimous approval of all concerned for these buildings as now built. Bids for construction were opened on October 15, 1946, and the contract was awarded to Consolidated Contractors for $84,857. I cannot speak too highly of Mr. B. M. Hayashi, who, for the contractors, drove the job to completion under most difficult conditions. Mr. J. C. Ripperton, agronomist with the University, took excellent care of the University's interests as University representative on the joint committee; the other members were Mr. Hebert, Dr. McKibben and Mr. Stirniman.

The funds available for the construction and equipment of the building were the original $100,000.00 gift plus $15,500.00 contributed by the Pineapple Research Institute. The University provided the site. Simple arithmetic discloses that $30,643.00 was available after letting the construction contract, for the payment of the usual construction extras — and the equipment. There were no extras so all the money became available for equipment. We have in these buildings $138,633.00 worth of equipment, we have $5,059.29 committed for payment for goods on order and we have in addition a cash balance of $5,759.73. That sounds somewhat like the loaves and the fishes but it is in large part a result of contributions made to the University from surplus Army and Navy equipment. This is where the benefits of University cooperation played a large part since the University could acquire surplus war material in ways which were denied to others. Donations from the U. S. Navy amounted in value to $40,792.00. Purchases from war surplus of $87,210.00 worth of equipment cost $9,633.00 plus $661.00 for student labor in reconditioning. $10,631.00 was paid for new equipment. We therefore have in these buildings and the equipment therein a plant valued at more than twice what it cost.

I must now retrace my steps a short distance to a conference called by Regent W. P. Alexander with Professor H. B. Walker in November, 1944. That conference was in effect the foundation of the Institute. It was Professor Walker's interest and enthusiasm which stimulated us to proceed with this building which we are now dedicating. He is here today to participate in our small ceremony. He will speak to us on a topic which is of major interest to all in Hawaii. It is with great pleasure that I present Prof. Walker to you.

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The Agricultural Engineering Institute and the University

An Address By

Harry B Walker, *Professor of Agricultural Engineering*
University of California

I esteem it a great honor to be present here today to participate with you in the dedication of this new and important addition to the University of Hawaii — The Agricultural Engineering Institute. This Institute is to establish its home

in the building before which we are now gathered and which, no doubt, will become the outward symbol of this new University activity. A building in itself is an inanimate thing, but it may possess beauty and character in its simple purposeful lines, as does this one — a triumph of architectural skill in functional planning. Within the shelter of its walls new activities are to occur, reflecting a growing recognition of the service of science to mankind by bringing into combination the physical and biological sciences for the advancement of agriculture. Let us hope also, this building may stand as evidence of the purposeful cooperation in the interests of agriculture, between those who made this structure possible and the commonwealth which has dignified and recognized this purpose by accepting it as a part of its University.

I visualize in this structure opportunities for the young men and women of these beautiful Islands who desire to enlarge their usefulness in the field of productive agriculture. I can, likewise, see within the walls of this structure, opportunities for engineers to translate scientific principles into activities of direct benefit to rural people. The usefulness of this Institute will be greatest no doubt to those who live in this immediate area. This is as it should be. But the University of Hawaii is a recognized cultural and scientific outpost for our Nation between the peoples of the East and the West, so this Institute we dedicate today must strengthen the University in meeting its broader obligations to society.

The achievements of our Nation in agriculture are noteworthy, and perhaps the envy of the world. In no other nation has the tiller of the soil been so respected, his labors so dignified, his output per unit of effort so great, and his individual rewards so large as here in this land of ours. During the period 1936 to 1946 output per farm worker in our Nation increased 50 per cent; farm output increased 40 per cent while the number of farm workers employed decreased 10 per cent. This has been due in no small measure to logical combinations of the sciences of agriculture and engineering applied to farming.

These words, agriculture and engineering used together identify the Institute we are dedicating today. I would not have you think these words so used lessen the importance of either; but rather, when used in combination, they identify a field of service to an industry which in itself is agriculture. Thus engineering, as such, is an adjunct to agriculture, but its importance in technical service is increased rather than diminished by this assignment.

Such technical service, however, has not simplified our social economy, but rather it has magnified the inter-responsibilities of farmers and workers who produce crops for the public's use. The failure of the farmer, or the worker, to carry out his responsibilities is soon reflected in the welfare of all the people. One hundred fifty years ago upwards of 90 per cent of our Nation's population was classed as rural; today only about 18 per cent is dependent directly upon agriculture for a livelihood, and the tendency is for this ratio to become less. This has placed grave responsibilities upon the man who farms, for the soil is the heritage of all mankind. In our Nation we have placed the responsibility for its use in the hands of a minority group, not only for the production of food and fiber needed by all of us, but also for the maintenance of our farm lands at a fertility level consistent with population needs and national security. Whether we have planned this consciously or not, the farmer in this modern world of

Fig. 2. Professor Harry B. Walker speaking at Dedication Ceremonies.

ours is a man of no small importance in our economy. The obvious purpose of this Institute is to serve directly the farmer and thus indirectly those who utilize the products of his labor.

Undoubtedly, this Institute will concern itself with those factors in agricultural production which influence the efficiency of labor and promote the most effective methods to encourage the earth to yield abundantly. Agricultural engineering, such as that to be fostered at this Institute, has been defined as the practical application of science and scientific methods to the industry of agriculture. Bear in mind that this definition implies the application of science in a practical sense as well as the use of scientific methods. We must admit, when so few of our population relatively are needed to produce crops, that modern farming is no longer a mode of life. Agriculture has joined the industrial class, but it remains a distinctive industry, responsive to the scientific approach. It is an industry which, if properly managed, is restorative in its production cycles, and thus under intelligent management there need not be serious depletion of the basic soil resources upon which it depends. In agriculture the materials and

Fig. 3. The Agricultural Engineering Institute at the University of Hawaii.

resources of nature are utilized in the production of crops of direct benefit to man. To use these materials effectively both the biological and physical sciences may be utilized to advantage. To obtain maximum benefits from these sciences combinations of agricultural and engineering techniques naturally develop.

In a sense, the farm, the plantation, and the ranch, are factories in the field, where power and labor costs often make up a large part of the cost of the products marketed. But here the products are developed as raw material; the power must be taken to the work in mobile units. and the operations must be timed to meet the habits of the plants and animals produced, and modified to meet climatic environments. Many of these operations are basically engineering in character, yet the measure of proficiency in these engineering applications must be evaluated in the end by biological responses, such as, tons of sugar, bushels of wheat, pounds of beef, or dozens of eggs.

Dr. Karl Compton, President of the Massachusetts Institute of Technology, has said of science and engineering, "Science seeks to understand nature; engineering seeks to control nature". This statement does not imply that engineers should neglect the basic sciences even though their field of effort is concerned primarily with the control of nature, for the better one understands nature, the better able one is to control its forces and utilize its materials. Therefore, it is fortunate this Institute is to be associated with a University where some of the members of its faculty are primarily concerned with understanding nature. Accordingly, let us hope that the Agricultural Engineering Institute of the University of Hawaii will become a common meeting ground for scientists, agriculturists and engineers. And, likewise, may we hope that the engineers whose major activities will be in this building will seek the laboratories of the agriculturists as well as those in related scientific fields in order that the frontiers of knowledge may be expanded constantly, and new findings translated into applications for the benefit of society. The integration of this Institute into the fabric of the University is, therefore, an essential condition for its success. It is a dependent Institution and not an independent one. It cannot operate efficiently by itself.

The agriculture of this Island region is distinctive and occupies an important place in the over-all Territorial economy. It is commendable that technical workers, representing your two principal cash income crops, are to be informally associated with the University staff in the Institute's work. The engineering problems of these great agricultural industries — sugar and pineapple — have many technical phases in common with the more general agricultural engineering problems of the region. Such coordinated effort among workers is common-sense procedure, and in keeping with modern trends. It is evidence of a mutual desire to accelerate technical progress. The various ways mechanical devices may be applied to purposes useful to agriculture are many and these multiply with experience in making applications. By having workers in these various activities centralized at this Institute, engineering experiences are more readily exchanged and ingenuity is encouraged in the solution of problems peculiar to the region.

Our Universities are the pride of our respective commonwealths. We have a right to expect of them both idealism and realism. They are expected to set the patterns for cultural and scientific development, and they should not be indifferent to the ever-changing social and economic patterns of the commonwealth which created them. The public will expect this Institute, located on this University Campus, to serve effectively in filling out this larger University pattern for public service. The nature of the work which will take place here will, no doubt, be closely related to the economic patterns of this area, which in turn must influence local social patterns.

Applied science has worked miracles for mankind and it has contributed much to human comfort and enjoyment. It has been, and continues to be, an effective tool in contributing to human plenty and to rewards for human industry. We would be deceiving ourselves, however, to assume that science and technology operating alone can solve completely the material and social needs of a war-torn world — a world now thrown into intimate social and economic relations through the implements of science.

Science — in itself — does not reason; it has no soul; and it does not under-

stand social justice. Fortunately, it is not subject to monopoly where men are permitted to think independently and are free to act in a truly democratic society. Most of the products of engineering skill, while based upon the inimitable laws of Nature are inanimate things, capable of use for good or evil depending upon the thoughts and subsequent actions of those who foster their development and use. This Institute will deal largely with material things as machines and appliances designed to reduce human effort and costs in the production of essential commodities needed by people. Labor-saving machines to merit that connotation must save labor. They may create labor, elsewhere, but generally, where

Fig. 4. Guests assembled at the Dedication Ceremonies.

machines exist, the need for workers for that particular task is lessened. However, with machines, working hours are normally decreased and output per worker and compensation increased. This fortunately has been the over-all record of our mechanical progress. But men will always be needed to control these machines through the exercise of skill coming from a trained intellect. Brawn is less appreciated today, and intelligence and skill become virtues. This adds dignity to labor. One of the important functions of this Institute will be to train men for these responsibilities.

The research work to be conducted at this Institute, because of its inherent nature, will be largely in the applied science field. It will be directed toward lightening the burdens of farm people and aiding them in carrying out their responsibilities to society; that is, the production of farm products of the quality

and quantity required by all of us at as low a cost as possible consistent with the responsibilities involved. The engineers, who conduct these investigations have an important role to fill. To them I commend the philosophy of Sir Francis Bacon, as expressed in his essay "The Interpretation of Nature and the Kingdom of Man:"

> "I possessed a passion for research
> a power of suspending judgment
> of meditating with pleasure
> of dissenting with caution
> of correcting false impressions with readiness
> and of arranging my thoughts with scrupulous pains
> I had no hankering after novelty
> and no blind admiration for antiquity
> Imposture in every shape I utterly detested
> For all these reasons I considered as it were
> a kind of kinship and connection with truth."

This Institute, located upon the Campus of the University of Hawaii of which it becomes a part, is dedicated to the welfare of this Island commonwealth through service to its agriculture. May I express the hope its purposes will bring to our citizens here, and elsewhere, pride of achievement; lasting benefits to all mankind both materially and socially; honor to this distinguished University; and lasting satisfaction to those whose foresight and generosity have made this day possible.

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Presentation Address

By William C. Rose, *Vice-President*
Hawaiian Sugar Planters' Association

A little more than fifty-two years ago what is now the Experiment Station of the Hawaiian Sugar Planters' Association had its beginnings. The records make no mention of any dedication. An office and a workroom were fitted out in a small downtown building. That was the birth of scientific agriculture in Hawaii. Most of us are familiar with the growth and the accomplishments of that institution. Also we know how significantly it has contributed to the development of the sugar industry.

The dedication of this new building is a similar milepost in the history of Island Agriculture. For the past 15 years or more, a gradual but persistent change has been taking place in the methods of cultivating and harvesting our sugar-cane fields. This change is generally referred to as mechanization, and was necessary to keep abreast of the ever-mounting cost of production. Greater quantities of sugar per acre and more cane per worker per day were essential if the cost of producing sugar was to be kept below the price for which that sugar was to be sold, and if the earning capacity of the workers was to keep in step with present-day living requirements.

Thus far this transition from hand to machine operation in the fields has not been rapid, though it has continued steadily. As each machine has released a certain number of men from performing hand labor, jobs have been created for skilled workers. Expediency forced the development of these skilled workers by on-the-job training, that is, by working with the machines as they were created

and perfected. The pace is now accelerated; and some two years ago responsible officials of the sugar industry foresaw the need of sound and well-planned training of its prospective workers while still in school. With that thought in mind, and to fittingly celebrate the fiftieth anniversary of the Association, the Trustees of the Hawaiian Sugar Planters' Association decided to offer the University of Hawaii a building in which could be centered the higher training of the youth of Hawaii for the agricultural livelihood offered in their homeland.

Fig. 5. Left to right: Dean H. A. Wadsworth, Professor Harry B. Walker, President Gregg Sinclair, Wm. C. Rose, and P. E. Spalding at Dedication Ceremonies.

The establishment of such a school as we are dedicating today is extremely fitting; not only because the schools of a community should train and prepare the youth of that community for the opportunities locally available, but because here Territorial isolation and other considerations influence a large percentage of Hawaii's young people to remain in the Islands.

If mechanization is the route to a more prosperous agriculture, it is likewise the route to better living for a large segment of the people of the Islands. This applies not only to the earning of a living, but to the mode of living. Our sugar

plantations have given and continue to give evidence of a sincere desire that their workers live well and happily. That is the basis of our efforts to cooperate with our schools and other facilities of the community in the training of our people for the betterment of their livelihood and the betterment of their way of living.

President Sinclair, it is a great privilege to bare this plate, and thus formally make known to the people of Hawaii this contribution of the sugar industry to the future agricultural education of its youth. We feel confident that with the wise and able guidance of you and your staff, the young men who receive the instruction to be given under this roof will profit by the training thus received and will become useful citizens and leaders to the benefit and credit of Hawaii Nei.

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Acceptance Address

By Gregg Sinclair, *President*
University of Hawaii

Mr. Spalding, Dr. Walker, General Rose, Ladies and Gentlemen:

In accepting for the University of Hawaii this finely adequate building, I wish first to express the Regents' appreciation to the Hawaiian Sugar Planters' Association for making possible an Institute that will permit coordinated research in a certain phase of agriculture. This is no duplication of facilities; nothing will be attempted here that will compete with the excellent work being done by the Hawaiian Sugar Planters' Association Experiment Station, or the Pineapple Research Institute or our own Agricultural Experiment Station. But in the utilization of power, the use of machines in the growing and harvesting of sugar, pineapple, truck crops, new methods may be developed. An opportunity is presented here, and the Coordinating Committee — Mr. Guillou, Mr. Stirniman, and Mr. McKibben — will doubtless take full advantage of that opportunity.

We anticipate that this building will be used for the training and education of agricultural students. We recognize that the basis of Hawaii's economy is agriculture, and that our students have a definite place in that economy. One of the Regents, Mr. J. Scott B. Pratt, has emphasized for three years the fact that college men, with training in mechanics as well as in agriculture, have a place in the plantation life of Hawaii; they *must* know the basic principles of mechanics and agriculture. With the creation last Spring of our College of Agriculture under Dean Harold A. Wadsworth, we mean to extend our instructional offerings in agriculture to make use of these fine facilities.

This building represents the first considerable gift to the University of Hawaii in recent years. It means a great deal to the University — much more than its money value. We confidently believe that the returns over the years will far outweigh the initial costs; and if the results are thus commensurate, we hope and believe that this spirit of cooperation will manifest itself again. We like this association of the University with the Hawaiian Sugar Planters' Association and the Pineapple Research Institute; we are anxious to have more cooperation. When our Graduate School for Tropical Agriculture begins to function, we hope to have associated on this faculty the scientists in each institution. This spirit of cooperation was highly commended last week by Secretary of Agriculture

Clinton Anderson when he examined the Agricultural Engineering Institute building. It is this spirit that we would like to foster, and this building exemplifies it.

We want the community to be proud of its University. We have endeavored and will continue to endeavor to put on our Faculty scientists and scholars of high quality; these men will put forth their best efforts if they are provided with proper tools, adequate facilities, satisfactory financial encouragement. This building is an earnest of the community's interest in utilizing the services of the University in a highly productive manner.

We are glad, therefore, to accept this building from the Hawaiian Sugar Planters' Association.

Fig. 6. Left to right: Professor Harry B. Walker, President Gregg Sinclair, and Dean H. A. Wadsworth.

Weed Control by 2,4-D with Notes on Application by Airplane

By H. R. Shaw, P. F. Conrad, Robert F. Amundsen and S. M. Tutton*

The rapid advance of mechanization in the Hawaiian sugar industry during the past ten years was more than justified during the war period when acute labor shortages and intensified production disrupted many industries. Mechanical harvesting, improved planting machines, more efficient irrigation methods and the development of transportation equipment for cane and supplies within the field have contributed greatly to the survival and progress of the Hawaiian sugar industry during a period of unusual stress.

With the possible exception of the perennial discussions on the effect of "grab" harvesting upon factory efficiency, there is no labor-saving field operation which has been open to greater controversy and honest doubt than the methods of weed control extended during the past decade to nearly all sugar plantations in Hawaii.

Mechanical cultivation with time-honored discs and tines is of limited value in the furrowed fields obstructed by ditches and concrete flumes on irrigated plantations. Even on unirrigated and some irrigated plantations where great progress has been made through the use of fast, high-clearance cultivator machines, there appears to be no permanent reduction of weed population. Furthermore, the necessity for proper timing of cultivation under uncertain weather conditions frequently nullifies an otherwise effective program of mechanical weed control.

In the field of chemical herbicides, the merits of present practices on Hawaiian plantations have been subject to even more serious question. There are many qualified observers who believe that the continued use of toxic chemicals which accumulate in the soil will result inevitably in yield depression and permanent damage to the land. Economically, however, the development of non-accumulative substances, such as emulsified Diesel oil in concentrations currently required, appears to be limited in scope because of the bulk of material required to serve the rapidly moving crews with knapsack sprays which now constitute the standard method of herbicide application on all irrigated and many unirrigated plantations.

With steadily increasing labor costs, moreover, there are obvious economic limits to the industry's ability to maintain indefinitely a weed-control program which is dependent upon relatively large groups of labor engaged in hand operations. It seems unlikely that the most efficient organization or greatest individual

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effort in knapsack spraying will result in performance exceeding five acres per man day while the task of hoe weeding not only has little appeal to modern labor but results not infrequently in costs which erase any margin of profit.

The advent of organic herbicides developed within very recent years consequently challenges the attention of all who are concerned with the improvement of agriculture, and demands the most thorough investigation and trial by scientists and field agriculturists alike.

Chief among the new developments available since the war has been the hormone dichlorophenoxyacetic acid, familiarly known as 2,4-D. The details of the origin and early research development of this amazing chemical still are shrouded in some of the war-time secrecy which attended its inception. Claims for its discovery still are in litigation but the results of field trials in many parts of the world have been so remarkable and so consistently effective that there is little purpose in citing the literature which has developed within the past two years on the use of 2,4-D as a weed killer. The principal points of interest to the agriculturist engaged in the commercial application of scientific developments are:

1. As a selective herbicide in proper dilutions, 2,4-D kills many broad-leaved plants without apparent damage to grasses including sugar cane.

2. As a pre-emergence herbicide, 2,4-D inhibits or prevents the germination and early growth of many seedlings.

3. There is no conclusive evidence to indicate that 2,4-D is toxic or harmful to man or animals.

4. The chemical may be used as a dust, in a water solution or in an oil emulsion with relatively equal effectiveness. It also may be combined with other herbicides if desired.

5. A permanent reduction of weed population is a greater possibility with 2,4-D, whose lethal action is internal and extends into the root system, than with herbicides which exercise an external, searing effect without necessarily curtailing subsequent root and plant growth.

6. The effect of 2,4-D is not accumulative nor stable and there is no evidence of permanent, residual toxicity to the soil. On the other hand, the effectiveness of 2,4-D is limited in time to a period variously estimated as from two weeks to 90 days depending upon the concentration applied, the soil type and the intervening weather conditions.

7. There is sufficient evidence in experimentation and in field practice with 2,4-D to demonstrate that it is an extremely potent, lethal material, and permanent damage to beneficial plants and trees may be incurred unless extreme care is exercised in its use.

Viewed even from the most conservative standpoint, the experience with 2,4-D to date clearly indicates that this chemical already has found a useful role in agriculture, that it gives rich promise of providing lasting control over the weed competition which proverbially has been one of the limiting factors in economical crop production and that, with the exercise of proper care and precautions, it has few of the disadvantages to the safety of man, the soil and beneficial plants which exist with the more stringent chemical herbicides now in general use.

The following account of field experimentation with 2,4-D on the sugar plantation of the Waialua Agricultural Company, Limited, makes no claim to

unique uses of the chemical which have not been employed elsewhere, including other plantations in Hawaii, nor to innovations in application methods which are not standard practice in many parts of the agricultural world. It attempts to emphasize by example, however, the need for cautious, progressive field experimentation with a chemical so potent and so relatively untried as 2,4-D; to summarize the results of field observations on weed control with 2,4-D specifically associated with sugar-cane agriculture; and to forecast conservatively practical methods of control employing 2,4-D which would lead toward a more effective and economical solution of one of the major items of expense in the production of sugar cane.

Field Tests with 2,4-D:

The first use of 2,4-D at Waialua occurred in April 1946, when a gallon of the ammonium salt of 100 per cent 2,4-D acid was supplied by the Chemistry Department, Experiment Station, H.S.P.A. for trial. Under the coined name of "Honocide", the material was recommended as a selective herbicide on honohono and nut grass.* Observation spraying of the solution on honohono at various rates of application demonstrated that it lived up to its name. Minimum concentrations of "Honocide" gave rapid and complete control of the weed although it was necessary to spray each tendril to prevent new rooted nodes from starting.

Additional amounts of "Honocide" were obtained for use by Division Overseers on ditch banks and gullies infested by honohono with the same excellent results. A comparative field test was designed and conducted by L. Kishinami, Irrigation Foreman of Opaeula Division, in a heavily infested drainage area. Kishinami divided the area into 13 plots of 125 square feet each, determined by trial as the area covered adequately with one gallon of solution applied by a Vermors knapsack sprayer. After providing alternate untreated check plots, he applied liquid "Honocide" at rates ranging from 1.1 to 8.7 pounds 100 per cent 2,4-D per acre. His daily observations of the reaction of the plant to the chemical, as noted in Table I, are of interest.

Additional field observation tests on honohono were made with "Honocide" under various plantation conditions and at different concentrations. Invariably the kill of this susceptible weed has been good with a minimum concentration of 1 gallon stock solution (14.5 pounds 100 per cent 2,4-D in 50 gallons water with 8 pounds ammonium hydroxide) to 31 gallons water.

The effectiveness of 2,4-D on nut grass is not as spectacular nor as consistent, however, as with many other weeds. A series of three field tests were installed in June, 1946 to measure the effect of "Honocide" on nut grass in one plant field and two ratoon fields. Treatment started as soon as cane germination was established in each area and continued for 12 weeks. The treatments in each series compared weekly sprayings of 0.5 pound per acre 100 per cent 2,4-D, semi-monthly applications of 1.0 pound per acre and monthly applications of 1.0 pound per acre. Each series received 9 weekly treatments, 7 semi-monthly treatments and 4 monthly treatments. Final analysis of the three tests indicated that the weekly and semi-monthly treatments were equal in effectiveness and

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* The common names in usage on Hawaiian plantations will be followed in this report. The equivalent botanical names and their relative susceptibility to 2,4-D will be found in Table III.

TABLE I

REACTION OF "HONOHONO" (*COMMELINA NUDIFLORA*) TO VARIOUS CONCENTRATIONS OF 2,4-D AMMONIUM SALT

Plot	3	5	7	9	11
Pounds 2,4-D/ac	1.1	2.2	4.4	6.5	8.7
Weather Conditions	Light showers second day after spraying. Warm slightly overcast for four days after spraying, followed by cold mornings and generally warm, clear days.				
2nd day after application	All treated plots have slightly yellow appearance and have lost vigor and erectness.				
3rd day	Leaves drooping	Leaves slightly dry	Leaves decidedly dry	Wilted and dry	Leaves flat and dry
4th day	Not much change	No change	No change	More yellow leaves than Plot 7	Drier, more leaves turning yellow
5th day	No change	No change	More yellow leaves appeared	Not much change	Yellow leaves turning brown
6th day	Slightly darker	Leaves are darker yellow	Leaves are darker yellow	Not much change	
7th day	More yellow leaves	Yellow and brown. Dying	Stems are dark. Some leaves brown	Slightly more yellow leaves	Leaves and stems completely dried up and dead
9th day	New growth starting	Lots of brown leaves dead but some new growth	Lots of dead brown leaves	About same condition as in Plot 7	Practically no green leaves showing
11th day	Yellow leaves now dry		More green leaves than Plot 9 but percentage of dead plants appears to be greater. This seems to be the most effective concentration for field control	Very few green leaves	No green leaves showing
13th day	About 50% dead but equal percentage have revived and are growing again	Not much change		Most are dry and brown	No signs of recovery or renewed growth
14th day				Remaining leaves with any color appear to be dying	
15th day		Good effect for light applications, almost as good as Plot 7 except for a few patches			Treatment very effective but not comparably greater than Plot 7

both were slightly better than the monthly application. The exposed portions of the plant died back and the top growth was kept under control so that at no time did the weed compete with cane growth but repeated applications did not eradicate nut grass and new growth developed without apparent hindrance.

Additional field tests were made with "Honocide" on standing growth and on newly cleared growth of koa haole with applications at the rate of 3.5 and 7 pounds per acre. The contact kill was reasonably good with the top growth and small seedlings becoming withered and dead but the effect was not permanent and new growth quickly developed from the old stumps.

The conclusion at the close of the 1946 experiments was that the ammonium salt of 2,4-D as "Honocide" was a fairly effective selective herbicide but that in this form it had limited utility at Waialua where honohono is quite thoroughly eradicated from practically all cane fields and is kept under control by existing cultivation methods. "Honocide" had not proved fully effective against nut grass and koa haole, and its known inability as a contact herbicide to control grass weeds prevented its consideration as a substitute for herbicides currently in use.

The reported use of 2,4-D as a pre-emergence control to prevent the germination of weed seeds stimulated new interest in the chemical. Several accounts in agricultural periodicals during the latter part of 1946 described effective methods of weed control by applying 2,4-D as a dust or in solution to the soil prior to the germination of any plants. Weed germination reportedly was controlled almost completely while the commercial crop was only slightly affected in occasional instances. Comparable results were gained by Ewa Plantation Company from small-scale tests in germination flats treated with various concentrations of 2,4-D.

A field test was installed at Waialua Plantation in February 1947 to compare in replicated tenth-acre plots 2,4-D as the 100 per cent acid dust mixed with inert Bentonite as a carrier at the rate of 10 pounds 2,4-D per acre broadcast over the entire area and at the same rate applied to the furrow banks only. Untreated check plots were included in each series of replicates. Applications were made shortly after planting and before germination of 37-1933 cane.

The control of weed germination in all treated plots was spectacular. Not only did broad-leaved weeds fail to germinate but many grass weeds were unable to develop. Further weed control was not necessary for a period of six weeks. However, a slight retarding effect on the germination rate of sugar cane was evident in the treated plots and examination of the seed pieces showed many of the nodal roots to be stunted and underdeveloped. While the depressing effect appeared to be temporary and the field closed in satisfactorily, the need for caution in the use of 2,4-D on plant fields prior to germination of cane seed was indicated by stalk counts made periodically in each plot area.

TABLE II

STALK DENSITY COUNTS AFTER 2,4-D TREATMENT
FIELD OPAEULA 3, PLANT 37-1933 CANE

Age of Cane	Stalks per foot		
	10 lbs./acre 2,4-D Broadcast	10 lbs./acre 2,4-D on Banks	Untreated Check Plots
7 weeks	1.14	1.37	1.62
3 months	4.07	5.52	6.55
5 months	4.71	5.11	5.43
6½ months	4.79	5.02	5.23

Contrasted with the retarding effect on cane germination observed in this test, many additional tests and observations with 2,4-D applied in moderate amounts to plant cane after germination was complete, and to ratoon cane at various ages, failed to indicate any depressing effect on cane growth or development. Apparently the critical period during which 2,4-D should be used with caution, if at all, in sugar cane is from the date of planting to that on which germination is complete.

A field test in a plant field of 37-1933 just after weeding at three months of age compared broadcast dust applications in Bentonite carrier of 2.5, 5.0 and 7.5 pounds 2,4-D per acre. The best control was gained at the 5-pound-per-acre rate. The lighter application was partially effective and the 7.5-pound-per-acre application showed no advantage in degree of control over the 5-pound-per-acre rate. No damaging effect on stand, growth or appearance of cane could be observed.

Comparison of 10 pounds 2,4-D dust per acre broadcast and on banks only was made in a field of 32-8560 ratoon cane. Application was made by rotary duster using Bentonite as a carrier immediately after the first irrigation was completed. A few seedling weeds had developed by the time the dust was applied. Not only was a complete control of weed germination established, but the newly developed weeds soon died back. The ratoon cane developed rapidly without evidence of ill effect on density or growth. No further weed control was required until a hand weeding was given six weeks after dusting. The untreated check plots contained heavy weed growth and the surrounding crop cane required two herbicide sprayings and a weeding within the six-week period.

In an effort to determine the minimum application of 2,4-D dust which would give satisfactory pre-emergence control of weeds, a test in a ratoon field compared 1, 2.5 and 5 pounds per acre applied as the ammonium salt solution of 2,4-D. Observation plots on the 80 per cent sodium salt of 2,4-D also were included. All applications were as solutions rather than as powder or dust. Applications were made immediately following field preparation but prior to first irrigation. The 5-pound-per-acre application controlled broad-leaved weeds but had no apparent effect on grass-weed germination. The lighter applications were relatively ineffective and did not appear adequate for field use. The sodium salt did not appear to be as effective as the more concentrated ammonium salt but replications of the former were limited.

The same form of test was repeated in an adjacent field of plant 32-8560 cane. At rates of 2.5 and of 5 pounds 2,4-D per acre, satisfactory weed control was maintained for four weeks after application. At one pound 2,4-D per acre as the ammonium salt, weed development was retarded but could not be considered effective plantation control.

Two field tests compared applications of 5 pounds 2,4-D per acre in three forms: 100 per cent acid dust, ammonium salt solution and the isopropyl ester of 2,4-D as an oil emulsion. Satisfactory pre-emergence weed control was gained for a period of four weeks by all three forms but the oil ester appeared slightly more effective with the dust application a close second while the ammonium salt solution was a rather poor third. None of the three forms affected density, growth or appearance of the plant 37-1933 cane in one test nor the 32-8560 ratoon cane in the other.

During early operations with the chemical, extra precautions were taken to

protect the men handling 2,4-D. Safety masks which cover eyes, nostrils and mouth were used during mixing and dusting. Neoprene gloves were used when handling the material. However, after several months of use it became apparent that the claims for non-toxic qualities of 2,4-D to men and animals were correct. The only discomforture experienced with the chemical has been a slight and temporary irritation of the eyes under some conditions when dusting with the 100 per cent acid. Further experience has indicated that special protective equipment may be disregarded with safety when using currently available forms of 2,4-D.

The damaging effect of the chemical on certain broad-leaved commercial and garden crops is a definite hazard, however, and may be the chief limiting factor in the use of 2,4-D. All field tests of the chemical at Waialua have been conducted with considerable caution in order to avoid damage to trees and to adjacent susceptible crops. Dusting has been limited to periods of quiet wind conditions or, frequently, by taking advantage of winds blowing away from other agricultural areas. Spray equipment used for 2,4-D has been segregated and marked so that it would not be used without thorough cleaning for other operations on or near susceptible useful plants.

In spite of every reasonable precaution, however, some damage has been caused to other plants although it has been extremely limited in amount and somewhat unpredictable in reaction to specific plants. During the test dusting in one of the upper plantation fields, an unexpected change in wind direction carried a small amount of 100 per cent 2,4-D acid about 300 feet onto a small garden plot planted in wasteland adjacent to the cane field. Dry-land taro, which by the nature of its broad-leaf surface and succulent stems should be one of the most susceptible plants, showed on the following day the typical twisted stem and flattened leaf of 2,4-D damage but within a week's time had recovered in vigor and normal growth habits. Cabbage, celery and newly planted tomatoes adjacent to the taro showed no reaction, possibly because the quantity of 2,4-D was minute and may not have reached these plants. An inspection of the area 11 weeks after the accidental application did not show any obvious, residual effect of 2,4-D on the taro or other plants.

A more serious and disturbing situation occurred in damage to pineapple plants following the air dusting of a neighboring cane field. The topographical situation was unusual in that pineapples were planted in a former cane field parallel to and on the leeward side of the cane area to be dusted instead of the more usual practice of pineapple plantings on higher elevations and windward of the cane plantation. Consequently, the air dusting was conducted with extraordinary caution. Flights were made only during the two hours after dawn when wind direction is from the southwest and away from the pine field at this location. Dusting was stopped as soon as wind direction started to shift toward the normal northeast trade winds. The airplane made sharp turns over the small gulch separating the two areas rather than banking over the pineapple field. Glass slides were placed along the edge of the pineapple plantings before the first day's dusting in order to discontinue applications if drift appeared to be carrying the chemical toward the susceptible crop. The pilot and ground crew congratulated themselves on a careful application with every normal precaution.

Nevertheless, obvious signs of 2,4-D damage developed in several of the

Fig. 1. Excessive amounts of 2,4-D on sugar cane will cause twisted stalk malformation.

Fig. 2. Sugar cane quickly recovers from excessive doses of 2,4-D and usually regains normal growth.

pineapple plants about 30 days after the dusting. The centers of damage were peculiarly distributed; instead of occurrence at the edge of the field nearest the cane area, plants on the high point of terraces seemed most vulnerable although no consistent pattern was discernible. A damaged plant frequently appeared in the midst of an area of apparently normal growing fruit. Nor were the symptoms of 2,4-D damage easily determined in pineapples. In the more obvious cases the peduncle of the fruit was distorted, upper leaves and occasionally entire tops could be pulled without effort from the plant, and rootlets had formed at the base of the leaves. More often, however, no symptoms could be suspected other than red-bronzed leaves and slightly twisted stems which also occur naturally under field conditions and could be found in localities where it was a physical impossibility for 2,4-D to have drifted. Consequently it has been extremely difficult to assay the extent of 2,4-D damage to pineapples in this instance or to survey accurately any pattern of drift occurrence.

After the early experience in which 2,4-D apparently affected the germination rate of newly planted sugar cane, further observation tests were conducted on the effect of excessive amounts of 2,4-D on sugar cane at various stages of growth. With dust applications of the 100 per cent 2,4-D acid in amounts approximating 60 to 80 pounds per acre, equivalent to gross error in dumping a supply load from the ground or air, it was possible to obtain the typical 2,4-D reaction of twisted and split stalks, reddened mid-rib and sheaf, and flattened leaf structure. The malformation was apparent only in cases where a considerable length of millable cane had formed. Within a month after treatment, the affected stalks had resumed upward growth and apparently were completely normal except for the pronounced bend in the stalk. No adverse effect on sugar cane, even under excessive dosages of 2.4-D, has been found in young cane prior to the formation of millable stalk.

It should again be emphasized that only under deliberate and excessive applications of 2,4-D far above any normal field treatment has any damage to growing cane been found. However, the potent and lethal effect of 2,4-D to certain other plants should not be minimized. The plantation scheme of agriculture with large, unbroken areas of the same crop undoubtedly is an advantage in the use of 2,4-D over the small fields and diverse crops of many mainland and European agricultural areas, but the avoidance of 2,4-D applications to areas in which any possible damage might occur to susceptible crops is advisable.

The general conclusions drawn by the Waialua field staff as the first series of field experiments were concluded during the summer of 1947 may be summarized as follows:

1. As a pre-emergence control of weed-seed germination, 2,4-D showed very great promise of becoming an effective control measure on a commercial scale.

2. Considerable caution in the use of 2,4-D was indicated by a depressing effect on cane germination observed when the chemical was applied immediately after planting and before cane seed germination took place. The damaging effect of 2,4-D on certain plants already was known. In addition to broad-leaved plants such as tomato and lettuce, already listed in the literature, certain tropical plants including pineapple, taro and papaia are known to be susceptible to damage from 2,4-D.

3. From preliminary field experiments, the 100 per cent 2,4-D as a powder

or dust appeared to be most effective as pre-emergence control of weeds including many grasses. The oil emulsion ester appeared promising as a contact spray and as pre-emergence control but supplies of this form have been limited to date. The water solution of the ammonium salt ("Honocide") was relatively ineffective as a pre-emergence control and only partially effective as a contact spray. This may be due in part to the relatively low concentration of 2,4-D in quantities of solution normally used in plantation field practice.

4. An application of 5 pounds 2,4-D per acre appeared to give adequate pre-emergence control. Application intensities up to 10 pounds per acre in ratoon cane gave excellent control without visible damage to the cane plant. Some evidence gathered would indicate that applications of 2.5 and 5 pounds per acre give satisfactory control in plant cane without depressing cane germination or growth, but further experimentation is required before applications to plant fields prior to the completion of germination can be recommended.

5. The limiting factors in the use of 2,4-D as a commercial plantation practice using traditional spray or dusting equipment on the ground are: (a) cost of material is at present inordinately high although a 20 per cent decrease in cost occurred during the period of experimentation and further reduction may be expected, (b) the concentration of 2,4-D required for effective pre-emergence control is such that stock solutions currently recommended are too dilute for economical field use of the water solution of the ammonium salt. It seems possible that the 44 per cent isopropyl ester (oil emulsion) may be sufficiently concentrated to compare favorably with the proportion of stock solution to water now used in plantation practice with other herbicides, and (c) limited experience with ground applications of the powder or dust form of 2,4-D through rotary dusters indicates that it may have possibilities in the field but the hazard of drift under windy conditions may limit its usefulness for constant operation by field crews.

Applications of 2,4-D By Airplane:

One of the criteria constantly in mind during the field experiments with various forms of 2,4-D has been the economics of weed control in terms of dollars, man-days and quantity of material required in contrast to present plantation standards using other herbicides.

An immediate objection to the soluble ammonium salt of 2,4-D, "Honocide," is the relatively great dilution of the stock solution. As a contact spray, more than four times the quantity of stock solution for double-strength "Honocide" must be transported to the field, carried by hand to accompany the knapsack spray crews and measured to each individual spray tank than is the case with herbicides in common use on Hawaiian sugar plantations. The logistic situation is even more difficult when "Honocide" is used as a pre-emergence control rather than as a contact spray because a total of 17.24 gallons of the stock solution must be supplied in order to apply 5 pounds per acre of the 2,4-D acid.

Comparable although less-pronounced difficulties attend the use of 2,4-D dust from ground-dusting equipment. The mixing of the chemical with talc or Bentonite, if a carrier is used, and the limited weight capacity of man-borne dusters require frequent handling and carrying of supplies. Even with the 44 per cent ester of 2,4-D which at a recommended dilution of 1:400 stock solution

to water is the nearest approach to current herbicide standards, the problem of reducing rather than maintaining present costs of herbicide application requires considerable study and organization.

The exceptional performance of 2,4-D in weed control, particularly in the prevention of weed germination, throughout the field tests described led to consideration of airplane applications of the chemical in order to approach a more economical solution. The use of aircraft for the application of herbicides and insecticides in certain mainland agricultural areas has been standard practice for many years and has recently received new impetus through the release of trained pilots after the war.

The advantages claimed for air applications over ground applications include: (1) greater speed of coverage, permitting rapid applications following periods of inclement weather when ground equipment cannot operate efficiently, (2) greater economy in man-hours and dollars per acre, especially in cases where large areas and consistent use of the machine are involved, and (3) potentially better distribution of material from air-borne rather than ground-borne equipment. The disadvantages usually enumerated are: (1) the hazards of low-altitude operations, (2) the "stand-by" costs of air equipment and skilled operators during periods of non-use, (3) limitations on the payload of airplanes which can operate efficiently at low altitudes, (4) relatively poor distribution from currently available equipment, particularly in the necessity for heavy applications immediately beneath the airplane in order to provide a minimum application at the lateral extremes of the swath, and (5) the hazards of drift by wind and propeller wash from areas under treatment to neighboring areas in which the chemical in use may be toxic.

Aircraft never have been used in Hawaii for agricultural purposes other than for distribution of seed in reforestation of inaccessible mountain areas and for limited experimental projects by individual pilots. Fortunately, a pilot connected with the Andrew Flying Service operating from the Haleiwa Airfield near Waialua Plantation had considerable experience in crop-dusting citrus areas in Florida and was interested in the possibilities of aircraft for agricultural purposes in Hawaii. Several preliminary flights at low altitude over the steep contour and irregular terrain of the plantation convinced the managements of the Flying Service and of the plantation that such operations were feasible. A standard dust hopper and distributor for light planes was obtained and installed by the Flying Service for collaborative experiments with the plantation.

The pilot's description of the equipment is as follows:

> At the present time, for experimental purposes, the dusting equipment consists of a standard stock-model Piper Cub J-3 with Continental 4-cylinder horizontally opposed 65-horsepower engine and Beech-Roby controllable pitch propeller, and a "Whitaker" Duster model J-3-B manufactured in Portland, Oregon, and approved by the Civil Aeronautics Authority, Department of Commerce, for installation in the standard stock model Piper Cub J-3. No major structural modifications are needed for installing the hopper, although minor fabric slashes and holes are made to accommodate the hopper and its accessories.
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> The hopper extends from the fuselage ceiling to the floor, and has sufficient cubic capacity to accommodate 300 pounds of 2,4-D or similar material. Since both the available aerodynamic lift and the engine power are insufficient to allow the necessary maneuverability when fully loaded under local conditions, the loads carried are less than capacity when dusting terrain which requires sharp pull-ups and long climbs.
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> Situated above the hopper, topside of the fuselage, is the loading door into which is dumped

the dusting material. About ten inches above floor level is a revolving agitator inside the hopper drum which keeps the material moving downward evenly. The agitator is powered by a small wind-driven propeller attached (with its reduction-gear box) to the left side of the fuselage. The small propeller turns at about 2100 r.p.m. and is geared down through the reduction box to an agitator speed of about one revolution per second.

These accessories were designed specifically for flat land use, where the wind source (propeller backwash) would remain constant. The equipment works well on the mainland, but occasionally to our disadvantage in Hawaii. Because local terrain requires many power changes which directly affect the accessories, design changes have been made to reduce any faulty operation of the hopper as it is used in Hawaii. A second agitator, chain driven from the same power source as the main agitator, was installed just above the valve release door to offset the tendency of the commercial type of 2,4-D, ungraded in powder or grain size and having no consistent specific gravity, to pack and harden in the hopper. This condition has resulted in a poor flow of material not only in hampering the downward flow of material but in causing binding and blocking of the agitator unit and valve door. A change in agitator design has improved the situation.

Just below floor level is a sliding wood panel which serves as a release valve and metering device. It is opened and closed by a release-valve handle mounted on the left side of the cockpit. The size of its opening is regulated by a cable-and-ball arrangement attached to the steel tube fuselage cross member and to the valve release handle. The 2-foot metering cable has 6 drilled ball bearings welded to the cable at $\frac{5}{8}$-inch intervals at the metering end; the far end is clamped to the fuselage. Each ball on the cable represents a variation of release-valve opening. The setting of the valve opening is made merely by slipping the correct ball into the keyhole slot attached to the valve-release handle and can be altered easily in flight. A secondary cable now installed gives greater degree of control on the valve as its metering is $\frac{5}{16}$-inch as compared with the $\frac{5}{8}$-inch on the original cable.

Below the floor level, outside the fuselage, is a venturi-like fitting which diffuses and spreads the material as it drops from the hopper. Additional changes probably will be necessary in this fitting to give a more even flow and distribution of the material. Directly above the valve are two throats which feed the venturi from either side of the center line and spread the material along the sides of the distribution swath, reducing concentration in its center.

Fig. 3. Dusting equipment used in experimental applications by airplane. Note agitator propeller and venturi spreader.

The distribution of material by the air-dusting equipment was studied on a segregated area of the Haleiwa Airfield. A strip 2,178 feet long and 120 feet wide was marked to give three flying courses, each with an area of exactly 2 acres on a 40-foot distribution swath. Using Bentonite, an inexpensive inert material with granular characteristics somewhat resembling 2,4-D powder, the plane flew the measured course with various discharge settings. Net dusting time was determined by stop-watch readings taken by observers at either end of the course and quantity of material was obtained by weighing the hopper load before and after running four courses with the same valve setting. Separate determinations were made at each valve setting within the range desired when the airplane was in level flight, climbing at a 5 per cent grade (equivalent to the average slope of Waialua highlands) and descending a 5 per cent slope.

Fig. 4. Supply hopper is conveniently located for rapid loading and has capacity for 200-300 pounds 2,4-D powder.

A measure of the uniformity of distribution was obtained by placing paraffin-coated glass slides at uniform distances throughout the measured area. The relative amount of material deposited on the slides was determined qualitatively after a single flight by atomizing an appropriate pH indicator on the slide. Bentonite is slightly alkaline and the color change produced by the indicator gave a reasonably reliable measure of the amount of material deposited by the plane. The same method was used in later field tests to determine the uniformity of distribution and the amount of drift of 2,4-D which is decidedly acid in reaction. The relative uniformity of distribution was satisfactory when the dusting plane

operated at less than 20 feet altitude under quiet wind conditions. Observation of the distribution pattern in flight confirmed that under such operating conditions the swath is 40 feet or more in width, and that the material tends to fall evenly and billow laterally close to the ground.

As a result of the preliminary tests, the pilot and ground observers agreed that: (1) the dusting equipment in general was satisfactory but capable of considerable improvement, especially in the control of discharge rate at various power settings, (2) the best flight altitude for dusting was from 10 to 20 feet above ground surface, (3) the most satisfactory air speed with the equipment available was 65 miles per hour, giving a flight application rate of 5.25 acres

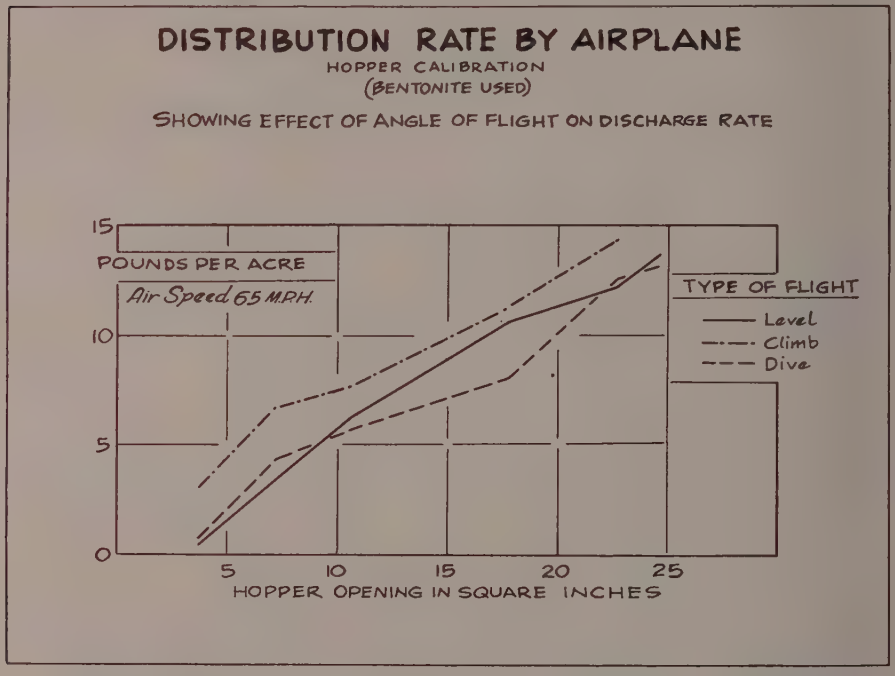

Fig. 5. Application rates were determined from calibration tests of discharge valve settings.

per minute of net flying time, (4) the disruption of distribution pattern was such that no commercial applications should be made during periods with wind velocities over 5 miles per hour, and (5) due to the variation in discharge rate with power setting, application flights on uneven terrain should be as nearly level as possible rather than following the undulations of the ground surface. When climbs and dives are required while dusting, the air speed should be kept as constant as possible and the discharge valve changed at the start of each direction of flight to give a compensating flow rate.

The first commercial flight to apply herbicide on Hawaiian cane fields was made on Friday, June 13, 1947 on 60 acres of Field Kawailoa 5. The 100 per cent acid 2,4-D was applied without a carrier or diluent at an average rate of 7.0 pounds per acre. The ability to use the 2,4-D acid directly from 100-pound

shipping cartons to airplane hopper is a distinct advantage in air applications as the cost, wastage and inconvenience of mixing and handling herbicide material is thus minimized. The field is on a 5 per cent slope and is bounded at top and bottom by irrigation supply canals which meander on a 0.1 per cent grade across the irregular terrain. Consequently it was impossible to plan level application flights across the field because of the number of pockets formed by the change in ditch direction which would have required short application runs and lowered efficiency. The dusting flights were run up and down the slope parallel to a field road which forms the eastern boundary of the treated area. A ground crew of two men, one stationed near the top of the field and the other near the bottom, paced a distance of 40 feet in straight lines at right angles to the boundary road after each flight. Each used a white paddle, resembling the visual control equipment on aircraft carriers, as a direction marker to the pilot who lined his plane for each flight on the line established by the two paddles. Later refinements of the ground-control methods resulted in laying the progress lines of the ground crew by transit at right angles to the base line prior to application and establishing temporary stakes at 200-foot intervals on each progress line as a check on the pacing distances of the ground crew.

Fig. 6. Close coordination and thorough "briefing" of pilot and ground crew are necessary for effective commercial work.

The mechanics of ground-air control in the first flight proved very satisfactory and have been used with little variation in later application flights. A simple series of hand and paddle signals indicate to the pilot any orders for repeat runs, increase or decrease of discharge opening, hopper adjustment or return for refill.

The necessity for operating up and down the field slope rather than on rela-

tively level cross-field flights proved to be a disadvantage in the first field trial. The rate of application in spite of manipulation of the discharge valve obviously varied in full-power climbs from that under reduced power on the descent even though air speed was relatively constant. The 60-acre area was completed without incident in 1.25 hours of flying time but the pilot and observers agreed that the application was far from perfect and that several improvements in technique and mechanics of application were required.

The pilot's summary of air-dusting flight methods after covering nearly 2,000 acres on the Islands of Oahu and Maui is:

Perfect flying conditions for dusting call for still air both horizontally and vertically. Flat ungraded terrain and straight squared fields make this type work exceptionally safe and easy; the ground work is simpler, and air work simpler and faster. As a whole, the Hawaiian Islands are quite mountainous and hilly, with very little flat land comparable to the great plains of mid-western United States. Special methods and equipment consequently must be devised to accomplish the job when imperfect conditions are encountered. Some of the techniques and methods developed in Hawaii would rarely be used on the mainland.

Differences in grade on rolling ground produce problems difficult for the dusting pilot to overcome. The airplane must be flown at constant air speed to maintain a constant feed and drop rate. Up- and down-hill flying, maintaining a consistent height above the ground, is in itself not difficult as variations of engine power will offset the problems of maintaining a constant air speed and altitude. But the variable power settings change the discharge rate as the speed of the agitator is affected by the airplane propeller backwash, turning faster at full throttle and slower at lower throttle settings. When the hopper is full and the throttle is set at full thrust, the dust output is good and the swath will be well laid. Reducing the engine power, and thereby slowing the speed of the agitator, produces a poor distribution pattern which is spotty and unsatisfactory. This condition is detected both by ground observers and the pilot in flight. Spotty distribution is due mainly to the packing tendencies of 2,4-D in the hopper just above the valve door, as described above. One expedient method of combatting this condition is for the pilot upon noting the poor discharge rate to move the valve release handle very rapidly fore and aft, disturbing the packed material and thereby aiding the drop rate. By this method faulty feeding has been almost eliminated. Faulty feeding can be completely eliminated through the use of an electrically driven constant speed agitator motor. This will not be affected by changes in power settings which are so necessary to the proper technique devised for the particular needs of Hawaii.

Abrupt changes in terrain, many cliffs, foothills and the like, cause much concern to the pilot and it will always be necessary to avoid these obstacles where possible. Generally these natural contours of Hawaii are not insurmountable obstacles, but at certain times due to weather conditions, even the least of these become "grave" prospects, literally and figuratively. Vertical air movements, popularly known as "bumps" or air pockets, are caused by the abrupt changes in terrain which disrupt horizontal air flow, and to a greater degree by uneven radiation of heat from the ground. The hazard involved is not so much the discomfort as the reduction of controllability of the airplane. The reduction is aerodynamic, and affects the efficiency of the airplane by about 20 per cent. Not knowing when to expect these weather conditions, the nervous tension of the pilot is considerably higher.

It is not difficult to deduce that perfect conditions for dusting are not common in Hawaii. The horizontal air mass movements are always present, as are vertical components, though they are both at a low ebb during the hours of darkness.

Airplane dusting under the described conditions is not as impossible or hazardous as it may appear. It need hardly be said that the risk level is very much higher here than on the mainland. All the enumerated conditions, plus the necessity of flying from five to ten feet above the ground, keep the pilot busy mentally and physically. Three hours' work under adverse conditions is equal to eight hours of manual labor measured in terms of fatigue.

To obtain the best weather conditions, work must start at dawn and continue until the field has been completed, or before adverse weather arises. On a poor morning only ten or twenty acres can be done, while on a good morning as many as 300 acres can be completed.

Slightly over 1,000 acres have been airdusted at Waialua during the 1947 season. A deliberate attempt has been made to choose areas which would give a variety of flying and application conditions and, within limits governed by the safety of the airplane and possible hazard to other crops, to test under actual field conditions the practical limitations of herbicide applications by aircraft.

A block of 158 acres on an average five per cent slope with irregular side hills and a tree-lined ravine within the field was airdusted in early July. Application runs were relatively long, averaging about a half-mile of continuous flight. Again the boundaries of the field prevented cross-ridge level flight and applications were made only during climbing flight in order that the discharge setting would be constant. The application was more uniform than in the first area dusted, averaging 7.6 pounds 2,4-D per acre, but application flow was lighter at the start of the run and increased as the power setting stabilized on the long flight up grade. Later inspections of the field confirmed that weed control was more uniform and

Fig. 7. Dusting starts at dawn to take advantage of quiet wind conditions.

thorough in the upper portion of the area than that receiving the first part of each application flight. The ravine and obstruction of trees did not constitute a handicap and irregular terrain was dusted without difficulty but there was a tendency for wind currents to follow the ravine, causing moderate drift away from the side hills. Collection slides placed along roads and field edges for approximately one mile to leeward of the field showed no indications of drift greater than 100 yards from the lower edge of the field.

The first cross-ridge application which permitted relatively level flight was made on August 14 on a field of 184 acres. Improvement in uniformity of application was immediately apparent, although increased experience and familiarity with the method undoubtedly contributed to the results. The field was completed with an application of 11.4 pounds 2,4-D per acre in three hours air time. The airplane operated without difficulty from a field road in the center of the area where it landed for refilling. Results in terms of weed control in this area were the best obtained in the commercial tests to that date. Except for some

"mop-up" applications by a three-man ground crew in small areas where the airplane could not operate satisfactorily, no further spraying or weeding charges were required in the area from the application date on August 14 until September 30 when a ground spraying was applied.

A heavy application of 15.4 pounds 2,4-D per acre was given on September 13 to a normally weedy area in which frequent light showers occurred after the application. Cross-ridge flights on level gradient were made. Application was uniform although the tendency for wind drift to follow and settle in the low areas of the field was noticeable. Control of weed germination was excellent.

Fig. 8. The dust holds close to the ground and billows laterally in a swath 40 or more feet wide when operating under quiet wind conditions.

The best criterion of uniformity of application and efficiency of airdusting has been based on frequent and intensive inspection of weed conditions in the field at regular intervals after the air application. The field map of each area dusted was divided into grids enclosing areas of approximately one-half acre each. Three weeks after the airdusting, the same observer inspected the field, reported the appearance of weeds in each grid, and made periodic weed counts. Every grid square was indicated on the map as: (1) control satisfactory; no further operations needed, (2) control fair; will need attention within a month, and (3) control poor; should have immediate attention. The areas of poor control, which invariably occurred near trees or other flight obstructions and decreased in size as greater application experience was gained, were "mopped up" by a crew of two or three men using knapsack sprays with a mixture of "CADE" 1:10 and "Honocide". By use of the control map, coverage was rapid and relatively inexpensive while the necessity of scheduling a complete ground application in order to eliminate a few patches of weeds was avoided.

TABLE III

RELATIVE REACTION OF COMMON WEEDS AT WAIALUA TO 2,4-D USED AS PRE-EMERGENCE CONTROL AND AS "HONOCIDE" CONTACT SPRAY

Common Name	Botanical Name	Pre-Emergence (100% Acid Dust)	Post-Emergence ("Honocide" Contact spray. Ammonium Soluble Salt)
Wire Grass, Goose Grass	*Eleusine indica*	Good	Poor
Graceful Spurge	*Euphorbia sp. (Bifida)*	Fair	Good
Rattlepod	*Crotalaria saltiana*	Fair	Good
Purslane, Pigweed	*Portulaca oleracea*	Good	Good
Amaranthus, Spiny	*Amaranthus spinosus*	Good	Good
Amaranthus, Spineless	*Amaranthus gracilis*	Good	Good
Garden Spurge	*Euphorbia hirta*	Good	Good
Nut Grass	*Cyperus rotundus*	Poor	Poor
Manienie	*Cynodon dactylon*	Poor	Poor
Flora's Paint Brush	*Emilia flammea*	Good	Good
Honohono	*Commelina nudiflora*	Good	Good
Koa Haole	*Leucaena glauca*	Good	Good

Cost of Air Applications:

The economics of weed control by herbicide applications from aircraft are somewhat difficult to establish with precision because of the experimental nature of the work to date and because the various forms of 2,4-D herbicide material are still under development with prices not yet stabilized.

Fig. 9. Trees and ravines do not form serious flight obstacles for skilled pilots.

The contract rate with the Flying Service which cooperated in the development of herbicide applications at Waialua was $3.00 per acre, including all costs of airplane service and maintenance, while the Plantation supplied material and groundcrew guidance. After a few months' experience the Flying Service offered

a contractual rate, which is currently in effect, based on continuity of service and total area covered per season as follows:

Total Area per Year over 8,000 acres	$1.50 per acre
Total Area per Year, 6,000 to 8,000 acres	1.75 per acre
Total Area per Year, 4,000 to 6,000 acres	2.00 per acre
Less than 4,000 acres per Year	2.25 per acre

Although the rates specified compare favorably with present herbicide application costs for organized knapsack spray crews, it seems probable that the cost of airplane applications may be reduced still further if future requirements permit comparable organization and scheduled coverage great enough in scope to permit development of better equipment and pilot training. The greatest economic advantage of airplane applications at present lies in the saving of man-days and growing time during peak periods following rainy weather or unusual labor demands for other operations. The advantages, above and beyond any small differential in application costs, of an implement with the ability to cover at a rate in excess of 100 acres per day large areas in which weed growth can be checked sufficiently to permit normal cane development until mechanical cultivation or hand weeding can complete control at a more favorable time, are obvious to anyone familiar with plantation operations.

The economic disadvantages of airplane applications are currently and probably temporarily in the distribution equipment rather than in the cost of aircraft operation. Gross application of material at 10 pounds per acre is more than double the amount shown by field tests to be sufficient for pre-emergence control but the higher application appears necessary in order to apply an adequate amount at the lateral extremes of the swath. The hazard of drift from the application area to adjacent ground, particularly if occupied by crops susceptible to 2,4-D, is the second and perhaps the greater disadvantage as it limits the number of hours of daily operation and frequently prevents entirely the use of the material. The use of spray solution rather than dust by air is completely feasible since pressure pumps with spray nozzles spaced along the wing tips are standard equipment readily installed on aircraft. The factor of weight of solution which must be carried in order to provide the equivalent amount of 2,4-D material, however, is one which limits greatly the effective pay load of the airplane and which lessens the desirability of spray equipment compared to the powder. With either form there is a definite need, probably soon obtainable as interest in airplane control of crops increases on the mainland and in Hawaii, for improved distributing equipment. An important contribution to better distribution would be standardized manufacturers' specifications for a uniform particle size sufficiently coarse to prevent or lessen the amount of drift under moderate wind conditions.

The rapid development of more concentrated and economical formulations of 2,4-D and the proportionate increase in efficiency of both ground- and air-distributing machinery makes hazardous any recommendation or forecast of eventual methods of weed control on a plantation scale. Considering only equipment and materials now readily available and under trial locally, a system of plantation weed control which in the opinion of the writers would be effective, economical and fundamentally sounder than present general practice, would be as follows.

For Plant Cane:

(1) "Santobrite" (36 pounds per acre) or "CADE" (1:16) ground broadcast by machine to provide partial pre-emergence control without injuring cane germination. Apply immediately after seed is covered, (2) at two months of age, after cane germination is complete, an airplane application of 5 pounds per acre 2,4-D as dust or spray. Should be preceded by a light weeding or cultivation if persistent grasses are developing, (3) at four months of age, a ground application by knapsack spray of 44 per cent oil emulsion ester of 2,4-D, (4) at six months, or just before field closes in, a final weeding or machine cultivation followed immediately by an air application of 5 pounds per acre 2,4-D, and (5) for "other cultivation" of interior ditches, flume sides and weedy areas during remainder of crop, knapsack sprayings of "CADE" plus 44 per cent 2,4-D ester on standing weed growth.

For Ratoon Cane:

(1) Immediately after ratoon preparation is completed, an airplane application of 10 pounds per acre 100 per cent 2,4-D acid, (2) at two months of age, a ground application by knapsack spray of "CADE" plus 44 per cent 2,4-D ester, (3) at five months of age or just before closing in, a weeding or machine cultivation followed by an airplane application of 5 pounds per acre 2,4-D as dust or spray, and (4) "other cultivation" control by "CADE" plus 44 per cent 2,4-D ester as required.

The year 1947 may be regarded as a most eventful one in the field of weed control in Hawaiian sugar-cane areas. Seldom in a comparable length of time have the developments in materials and methods of applications for any plantation operation been so rapid and promising. That there will be many improvements and refinements as laboratory and field experience develops goes without saying but, for the first time, there is definite proved assurance of effective methods of chemical weed control without danger to soils or men.

A History of the Experiment Station of the Hawaiian Sugar Planters' Association 1895-1945

By A. R. Grammer

The following history of the Experiment Station of the Hawaiian Sugar Planters' Association has been compiled from records on file at the Station. A large part has been taken from published and unpublished reports and radio talks by Harold L. Lyon, A. L. Dean, H. P. Agee, R. A. Cooke, Sr., and P. E. Spalding. Items have also been extracted from "King Cane" *by John W. Vandercook,* The Planters' Monthly, The Hawaiian Planters' Record, Proceedings of the Hawaiian Sugar Planters' Association, *Minutes of the Experiment Station Committee, H.S.P.A., and the Experiment Station's Library Project Files.*

The Experiment Station of the Hawaiian Sugar Planters' Association was founded in the days of the Republic of Hawaii on April 2, 1895, that being the date that Dr. Walter Maxwell arrived at the port of Honolulu as the first Director of the Station and took up his work in science applied to sugar-cane culture and production. In order that we may understand better the need for the establishment of a sugar-cane experiment station in the Hawaiian Islands, perhaps it would be well to look into the earliest history of the Islands as extracted from an article by Dr. Lyon:

"When the Polynesians made their first landing on the shores of these Islands, they found a native vegetation that afforded them no substantial food whatsoever. The surrounding ocean supplied them with fish and limu in abundance, but on land they found no attractive fruits, seeds, tubers or roots to supplement their diet of sea food. However, the Polynesian Pilgrims undoubtedly brought with them to Hawaii the taro and sweet potato as these were the staple foods with which they stocked their larders when embarking on voyages in search of new lands. Once established in Hawaii, the Hawaiians made ocean voyages to and from Tahiti and introduced from that region economic plants with which they diversified their agriculture. When the white man established himself in Hawaii and took stock of the existing agriculture, he found that only twelve food plants had been introduced and successfully propagated by the Hawaiians. Sugar cane was one of these plants.

"The Hawaiian Islands, in their virgin state, were practically devoid of plant and animal products that would support human life. Any community on a Pacific island, to be self-supporting, must derive from the natural resources of its island the wherewithal to provide all of the necessities and comforts of life. There was one and only one means by which the inhabitants of the Hawaiian Islands could possibly achieve self support and that was by farming and, to farm successfully, they had to introduce plants and animals from abroad.

"Ranching was the first agricultural enterprise which proved profitable in the Hawaiian Islands. It produced commodities which could be shipped and sold, but ranching, of all agricultural enterprises, brings the lowest return per acre involved, and so it was soon evident that Hawaii could never become prosperous if all available lands were devoted to ranching.

"As previously mentioned, the Hawaiians had introduced sugar cane into Hawaii and demonstrated that it could be grown successfully. Since it was a crop that produced a choice food product that could be shipped to distant markets, its culture on a field scale was started as early as 1800 and has continued uninterruptedly up to the present time. Sugar-cane farming has maintained for itself the distinction of being the number one farm crop of these Islands. It gained this prestige without great difficulty because sugar cane soon proved to be the only available crop that could be grown profitably under the severe conditions imposed upon plants grown on the lands which were available for cultivation and, consequently, Hawaiian farmers were forced by nature, if not by choice, to concentrate on the cultivation of sugar cane.

"Recorded history shows that throughout the past century and a quarter, Hawaii has constantly fostered the introduction of economic plants from other parts of the world and, after their introduction, has cheerfully financed serious attempts to cultivate these plants in the hope that they might compete with sugar cane.

"Hawaii has also endeavored to grow a balanced food supply by trying to cultivate on the cane lands every food crop known to man, drawing planting material from every part of the temperate and torrid zones. These endeavors have been continuous and well conducted but in most cases have proved unprofitable. Suffice it to say that no crop has as yet been found that can displace sugar cane in Hawaii on lands suitable for its culture.

"However, these Islands in their virgin state did not, and do not now, afford ideal conditions for sugar-cane culture. Their soils were low in fertility and the very uneven topography of the lands made field operations difficult; rainfall was extremely variable. The early farmers of Hawaii recognized these difficulties which would have discouraged many men, but they were determined to grow cane and make sugar despite the great obstacles which had to be overcome. They wrested from the soil the necessary wealth to finance the growth of their industry, for instance, the expensive and intricate irrigation systems which converted desert lands into luxurious fields. Furthermore, they have consistently reinvested their profits in the industry and in other enterprises in these Islands. No community in the world began with so little in the way of natural resources as did Hawaii and no other community in the world has developed from such slender resources such an abundance as we now enjoy in these Islands — and that abundance has come to us through sugar."

Even with the partial overcoming of such natural obstacles as non-fertile soil, variable rainfall, and uneven topography of the lands, all was not clear sailing for the sugar-cane farmers. Sugar cane is a living organism. It is therefore subject to all the vicissitudes of life. If it is fed improperly it will sicken, if it is attacked by disease it will likely die, if its inheritance is bad, it will deteriorate and its strength will lessen. Insects feed on it and epidemic visitations of insects can utterly destroy it and the industry that depends on it. Weeds can choke

cane in its frail infancy and, furthermore, sugar cane can survive all of these risks and still lose money for the farmer.

Sugar planters in Hawaii learned early that they must add plant foods to the soil in order to obtain good crops. The necessary fertilizers were not to be found in the Islands, so the planters had to import them. In those days only crude materials were available and the plant-food value of any one consignment imported was apt to be different from that of all other consignments. Thus, the early planters were confronted with two closely related problems which they considered most important. They wanted to know what plant foods their soils required, and also how much of each of those foods they actually obtained in the fertilizers which they purchased.

These were problems for chemists to solve, and now we shall learn how the sugar-cane farmers of Hawaii proposed to solve their difficulties.

First, let us go back to the early eighties — to be specific March 20, 1882. On this date we find that the Minister for the Kingdom of Hawaii ". . . with the advice and consent of the King in Privy Council and by the authority in me vested by law, do hereby constitute the said EDWARD P. ADAMS, WILLIAM H. BAILEY, WILLIAM G. IRWIN, SAMUEL T. ALEXANDER, ALFRED S. HARTWELL, JOHN H. PATY, Z. S. SPALDING, their associates and successors a body corporate under the name of The Planters' Labor and Supply Company . . .". The following firms, representing the sugar growers of Hawaii were instrumental in obtaining the above-mentioned charter: Castle and Cooke, Bishop and Company, H. Hackfeld and Company (now American Factors, Ltd.), C. Brewer and Company, Theo. H. Davies and Company, G. W. Macfarlane and Company, Wm. G. Irwin and Company, F. A. Schaefer and Company, and E. P. Adams.

Cooperation was the keynote of the new organization and cooperation has always been the outstanding characteristic of the sugar industry in Hawaii. The whole philosophy of the industry may be found in the report of the Trustees of The Planters' Labor and Supply Company at the first annual meeting held in October 1882. "First of all they must be united. The jealousies of nationality, of location, of different degrees of success in business, should all be sunk in the general desire for the welfare of the whole. And as it is not to be expected that all eyes will see alike, the majority should rule and the rest acquiesce in such manner as to make the decision perfect."

We now come to the year of 1895 when two important developments occurred. One was the change in name and character of the organization known as The Planters' Labor and Supply Company, a corporation, to an unincorporated organization under the name of *The Hawaiian Sugar Planters' Association.* The second development was that of starting the scientific institution that has since come to be known as the *Experiment Station of the H.S.P.A.*

Thus the Experiment Station of the H.S.P.A. had its beginnings in an era when farm science was theory, separated from farm practice by a great gulf of unbelief. Truly, the founders of the Experiment Station had a breadth of vision in the necessity for untrammeled research which was extraordinary.

However, the establishment of an Experiment Station was not a spur-of-the-moment decision. At the first convention (1882) of The Planters' Labor and Supply Company, we find reference to what may be considered a thin entering

wedge of science applied to the Hawaiian sugar industry. It took form in a resolution, "That the Trustees be requested to consider the advisability of employing a thoroughly competent chemist to reside on these Islands, and do such chemical work as may be for the advantage of planters and manufacturers." Apparently no action was taken on this resolution.

Nevertheless, interest in chemists and experiment stations did not entirely cease, for at sessions of the planters' meetings in the 1880's and early 1890's, the wisdom of embarking upon a scientific venture, which such an experiment station would undoubtedly encompass, was seriously discussed.

A decade later we find Edward C. Shorey, chemist at the Kohala Sugar Company, in a letter dated October 6, 1892 to H. M. Whitney, Esq., editor of *The Planters' Monthly*, inquiring as to whether or not the establishment of an Experiment Station would come within the province of The Planters' Labor and Supply Company.

Then at the annual meeting of The Planters' Labor and Supply Company held in Honolulu on November 16 and 17, 1892 we find the first official action regarding an experiment station taken by the sugar planters. The Committee on Fertilization — J. F. Hackfeld, Geo. F. Renton, W. H. Rickard — presented its views in a report dated November 10, 1892. "There is need of a chemist to serve the plantations and there is need of an experiment station with a laboratory."

The members of the Committee on Fertilization supported their views by reading letters from L. L. Van Slyke of the New York Agricultural Experiment Station at Geneva, and from Dr. W. C. Stubbs of the Louisiana Sugar Experiment Station. Dr. Van Slyke said in part, "There should be headquarters with chemical laboratory, a kind of central station, and then a large portion of the work should be in the way of cooperation by the different planters in carrying out experiments planned by the director. Special experiments should be carried on at the central station." Dr. Stubbs urged a chemist, a laboratory and ". . . if you desire extensive experiments in sugar, bananas, rice, coffee and pineapples, you would have to combine an expert agriculturist with your chemist. . ." Appended letters from Mr. Renton and L. Ahlborn supporting the need for a chemist and an experimental station were also read. The Committee on Fertilization ended its report with the plea, ". . . we earnestly recommend this matter to your attention. . ."

The annual meeting of The Planters' Labor and Supply Company for 1893 had been delayed until January 22, 1894 at which time the planters met in the Hall of the Honolulu Chamber of Commerce. At this meeting C. Bolte, a member of the Board of Trustees, presented and read a communication regarding an experimental station. This communication read in part:

"To the President of The Planters' Labor and Supply Company:

"Sir:—The undersigned would again draw the attention of The Planters' Labor and Supply Company to the recommendations made on November 10th last year, by the Committee on Fertilizers, regarding the establishment of an 'Experimental Station'. It seems that almost all interested in sugar admit the advisability, or even necessity of such a station, but no steps having been taken we would now lay before you the following definite plan, the adoption and carry-

ing out of which, with such modifications as may be found advisable, we most earnestly recommend.

"Let a special committee of The Planters' Labor and Supply Company be appointed, with power to act, and let this Committee enter into negotiations with parties interested, for the purpose of establishing an 'Experiment' Station . . ."

This communication was signed by M. S. Grinbaum and Company, W. G. Irwin and Company, C. Brewer and Company, H. Hackfeld and Company, F. A. Schaefer and Company, Castle and Cooke, and Theo. H. Davies and Company.

During the discussion that followed, H. F. Glade said that the subject of an experimental station was so important that it should not be mixed up with anything else and H. P. Baldwin supported Mr. Glade's views. F. M. Swanzy estimated that an experimental station would require a large sum of money, not less than $8,000 for the laboratory alone and, after some further discussion, a special committee, consisting of Messrs. Glade, Bolte and Baldwin, was appointed to investigate the matter of an experimental station and report to the Trustees. Again we find the Committee on Fertilization warmly endorsing the project of an experimental station. Mr. Swanzy read the report of the Committee —W. W. Goodale, W. G. Irwin and himself — the last paragraph of which reads as follows: "This suggested experimental station is no discovery of your committee. By many others and for several years the establishment of such a station has been spoken of as 'a long desired want,' but our want is still unfilled. Your committee once again urges on the company to take into immediate consideration the establishment of an experimental station, which would surely be of great benefit to these islands in very many ways, not the least of which would be the lightening of the labors of your future committees on fertilizers."

The thirteenth annual meeting of The Planters' Company was held in Honolulu on Monday, November 5, 1894. The attendance at the opening session was larger than had been the case for some years, and nearly all the plantations were represented by their agents or managers. Mr. Irwin, Esq., presided, with Mr. Bolte, secretary, and Mr. Swanzy, treasurer, also at the desk. The secretary's report contains the following paragraph regarding an experimental station laboratory. "The Trustees have been in correspondence with Dr. Stubbs of the Louisiana Sugar Experiment Station with the view of procuring the services of an experienced agricultural Chemist who might travel about among the different Plantations giving advice to Managers about fertilization and other matters and who should have a laboratory in Honolulu where a younger Chemist would help him to do the analytical work. The Trustees desire to mention here that Dr. Stubbs has taken great pains in this matter and shown great interest in our affairs and that they are much indebted to him for the valuable aid and information he had rendered."

At the second-day session on Tuesday, with President F. A. Schaefer in the chair, Mr. Baldwin brought up the matter of providing ways and means for the expenses of a laboratory and chemist, and proposed an assessment of five cents per ton for general expenses, and five cents a ton for a laboratory and chemist. Discussion was held on salaries of the proposed chemists and a location for a station, but upon one point they were all in agreement and that was, "They

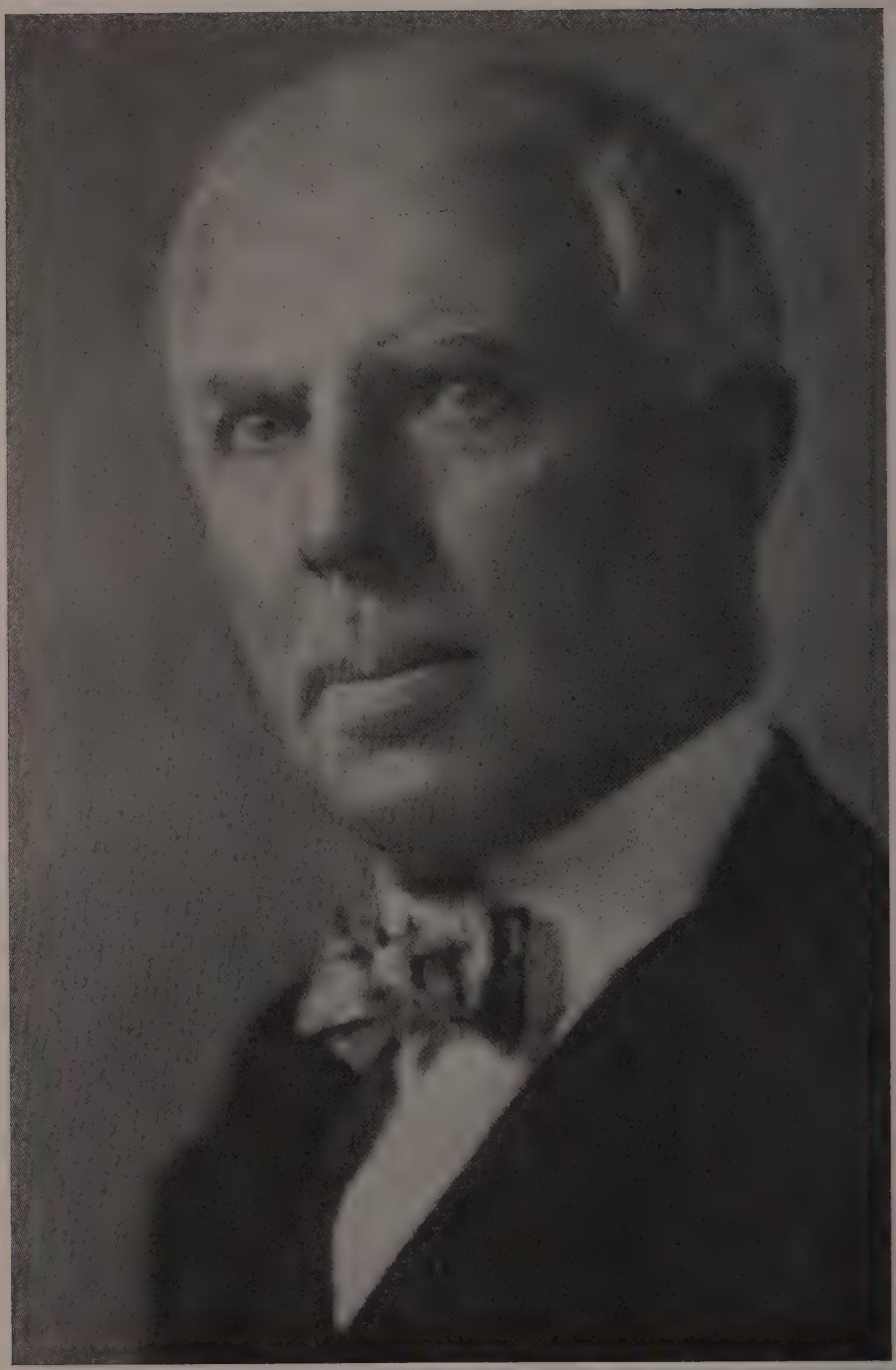

Fig. 1. Dr. Walter Maxwell, Director, 1895 — 1900.

wanted as head of the station, not only a chemist but an agriculturist — an agricultural chemist."

The negotiations with Dr. Stubbs resulted in his recommendation that Dr. Walter Maxwell, then of the Louisiana station, be engaged to develop and direct the experimental station work in Hawaii. In an article entitled "An Agricultural Chemist" published in April 1895, we find that Dr. Maxwell arrived in Honolulu on April 2nd on the steamship *China* and was staying at the Royal Hawaiian Hotel. Dr. Maxwell's qualifications are listed in brief as follows: Five years of practical service in Germany in the analysis of beets and beet-sugar soils; four years in Washington as special agriculture expert, during which time he established and directed the United States Government sugar station at Schuyler, Nebraska; and the past two years in Louisiana where he was employed as professor of chemistry and expert in sugar work. The article ends, "We congratulate the agricultural and planting interests of Hawaii on the arrival of an agricultural chemist, and trust that he will be able to satisfy the expectations of both the Government and the planters, who are jointly interested in this progressive movement, which promises to be of advantage to every branch of our industries."

In May 1895 we find that J. T. Crawley had arrived on the steamship *Alameda* on the 9th of that month, and that he had been selected by Dr. Maxwell as his assistant. Mr. Crawley graduated in science from Harvard University and was also employed at the Louisiana Experiment Station. We also find that, "The laboratory and office of the new experiment station have been fitted up and opened on the ground floor of the Robinson building, corner of Nuuanu and King streets. The entrance is at the south front door, on Nuuanu street, the store formerly occupied by Afong and Chulan." Later we find that the premises includes a reading room ". . . where various periodicals and other literature pertaining to the sugar industry are kept on file for the convenience of the members of The Planters' Labor and Supply Company."

With rare vision of the future, retiring President Schaefer in his address to the members of The Planters' Labor and Supply Company at its fourteenth annual meeting had this to say about the newly established experiment station, "The sphere of this station may be enlarged in various directions, and it will be left to your judgment to decide where the limits should be drawn, and where the immediate extension of operations in this line may be made to the best advantage."

By the time of the annual meeting of 1895 on November 26 (fourteenth annual meeting of The Planters' Labor and Supply Company and the meeting where the Hawaiian Sugar Planters' Association was organized to supplant it), Dr. Maxwell had visited all the Islands and nearly all the plantations. At this meeting, held in the association's new premises "on the lower floor of the Robinson Block, where are located the laboratory rooms and the office of Dr. Maxwell" he presented lengthy reports on soils, fertilization, and on fermentation losses in the sugar factory, and was appointed Chairman of the Committees on Fertilization, Cultivation, and Manufacture.

In December 1895 the staff of the station was increased by the addition of C. F. Eckart as second Assistant Chemist, and we also note that the sugar production for this year was estimated at 149,627 tons.

President Swanzy opened the fifteenth annual meeting of the Hawaiian Sugar

Planters' Association on November 16, 1896. He congratulated the members on the splendid results attained during a sugar season such as these Islands never before witnessed. He stated, "When we consider that ten years ago the sugar export was 108,000 tons, and that five years ago it was 137,000 tons there is every reason for a feeling of satisfaction on reaching the figures of this past season during which a very large acreage of cane has been safely harvested, and

Fig. 2. The Experiment Station, H.S.P.A. about 1900.

over 225,000 tons of sugar have been exported. Since our last session much good and valuable work has been done by what I may style the scientific department of our Association, and many planters are indebted for a measure of their present success to the careful and painstaking advice which they have received from this department." Dr. Maxwell had prepared a short statement regarding the work of the laboratory for the coming year. This included besides the examination of fertilizers, sugars, and sugar-house products, the continuation of studies on Hawaiian soils. He also spoke on the acquirement of a suitable tract of land for carrying out of practical agricultural experiments and we quote, "The land required for field experimentation has been secured. The field has already been enclosed by a high and strong railed fence. An old cottage already upon the land has been put into order for use of the laborers. A new building has been erected which includes accommodations for the foreman in charge of labor, a room for cane analysis, with a small room for storage, etc. The field has been broken up and buried butts of trees gotten out, and the land cleared and levelled. This preparatory work has been done in order to bring the land into the most perfect state of homogeneousness, without which strictly comparative experiments, side by side, are not possible. Also, on account of the bad mechanical state into which parts of the land has been brought through excessive irrigation by Chinamen growing truck, the land has been ploughed and cross-ploughed to a depth of eighteen inches and thoroughly exposed to the sun and air. During the next few weeks, trees overshadowing the land will be removed, the borders of the land put in shape, roads laid out, the fence and houses protected against the weather, and piping for irrigation laid in." Dr. Maxwell stated that he had planned experiments on fertilization, to observe the action of potash, phosphoric acid, and nitrogen individually, and also to note the action of these bodies in different combinations. The trials would be made with Lahaina and Rose Bamboo canes. Part of the land was to be used in fallowing and green fertilizing experiments.

The suitable tract of land mentioned in Dr. Maxwell's report is part of the Experiment Station grounds today. It was a tract of 4.229 acres bounded by Keeaumoku Street, Wilder Avenue, and Makiki Street, and was leased from the Dowager-Queen Kapiolani.

In Director Maxwell's annual report for 1897 we find that the chemical analyses in the fertilizer and soil work were made by Mr. Crawley, first Assistant Chemist, and Mr. Eckart, second Assistant Chemist; the physical examinations of soils, and the examinations of sugars were made by the Director; and in the field the Director was assisted by E. G. Clarke, field assistant. We also note that the islands have produced their first quarter-million-ton crop of sugar, the production for 1897 amounting to 251,126 tons.

The following item, published in November 1898, is of more than passing interest: "Dr. Walter Maxwell of this city has been appointed by the secretary of the Department of Agriculture in Washington, to be an honorary special agent in Hawaii. It will be his duty to report to the Secretary on the scientific aspects of Hawaiian agriculture, including the cultivation of sugar cane, coffee, fruits, vegetables, live stock, etc. The annexation of Hawaii to the American Republic naturally brings us into close relation with the national government, and we shall gradually share the many benefits to be derived from it."

The Director's annual report for 1898 reviews the work on fertilization, and

irrigation and states that the Station has begun the comparative examination of cane varieties. The varieties under observation were Lahaina, Rose Bamboo, Yellow Caledonia, Yellow Bamboo, Fiji Purple, Striped Singapore, Big Ribbon, 3 Louisiana varieties, 3 Demerara varieties, and 5 native canes. The Experiment Station staff was the same as for 1897, but a notation was made to the effect that First Assistant Crawley's services would not be available after the end of 1898 as he had accepted an important position with a large commercial enterprise.

In November 1899 it was reported that the Director of the Experiment Station expected to leave for Queensland on December 6th. "Dr. Maxwell goes in response to the government of Queensland which has asked him to visit the colony to inspect their conditions, and advise the Agricultural Department of the Government in the matter of establishing Experiment Stations and Laboratories." Dr. Maxwell expected to be absent about ten weeks.

The first official record of the members of the Association visiting the Experiment Station in a body was reported in 1899. The annual meeting of the H.S.P.A. was in session on Monday morning, November 20, and Dr. Maxwell extended an invitation to visit the Station the next morning. The account of the visit reads, "At 9 o'clock, some thirty sugar planters left the association hall, in carriages, to visit the Experiment Station, which is located at the junction of Wilder Avenue and Makiki street, near Punahou. The land covers several acres of the finest soil on the island, and is well adapted for the purpose to which it is devoted. The whole plot is under cultivation, and the arrangements for properly irrigating and fertilizing the various crops are apparently perfect. The visitors were personally conducted by Dr. Maxwell, who explained in detail the various methods by which he has been testing irrigation, fertilization and dry cultivation, notably with Lahaina and Rose Bamboo cane."

Another incident regarding the Station occurred in December 1899. At that time it was reported that a proposition had been informally made by the United States Agricultural Department at Washington to the Hawaiian Sugar Planters' Association to take over the Experimental Station already established here and combine it with a United States Station, which it was proposed to establish in the Islands. The suggestion had been favorably received by the Trustees of the Association, and correspondence was opened to ascertain what the proposal of the Federal Government might be. It was felt that the ample resources possessed by the Federal Government, if they could be brought to assist our leading industries, would be of great advantage to Hawaii.

We note that the Experiment Station staff at the end of 1899 was composed of Dr. Maxwell, Mr. Eckart, Firman Thompson, and R. M. Robertson.

At the turn of the century we find many changes in the personnel of the Experiment Station. *The Planters' Monthly* for May 1900 carries an item entitled "Dr. Maxwell's Resignation," and goes on to read, "The resignation of Dr. Maxwell, who has been in the services of the Hawaiian Sugar Planters' Association and of the Government for the past five years, has been announced, and he will leave for Queensland during the coming autumn, having accepted a position under the Queensland Government similar to that which he has held here." While Dr. Maxwell's resignation was apparently accepted by the Association in April 1900, he continued his duties as Director until the end of October of that year. This is indicated by items in *The Planters' Monthly* and the pay-roll

records for that period. In October 1900, it was reported that Dr. Maxwell expected to leave for Queensland on the steamer *Alameda* due in Honolulu November 6. He left Hawaii with the best wishes of the Association for success in his new position. Special congratulatory letters to Dr. Maxwell from Mr. Schaefer, President of the Hawaiian Sugar Planters' Association, and from Governor Dole were published in *The Planters' Monthly* for November 1900.

Dr. Maxwell was succeeded as Director by R. E. Blouin. We find the following report regarding Mr. Blouin, "Dr. Stubbs made the selection, and speaks very highly of him. He has been associated with the doctor for some ten years past, as his chief assistant, and is familiar with all the duties devolving on the incumbent of such a position." Mr. Blouin started on active duty at the Experiment Station on October 21, 1900 and by the end of that year we note that Messrs. Thompson and Robertson had resigned to accept other positions in the Islands, E. G. Clarke was again on the payroll, and S. S. Peck had joined the Station staff as second chemist. Mr. Eckart was First Chemist.

Two other incidents are recorded in November and December for 1900 that are of interest to the Experiment Station. The Twentieth Annual Meeting of the H.S.P.A. was held in the spacious hall of the Y.M.C.A.—"a central and very convenient place"— as the premises formerly occupied by the Association had been leased for a printing office. President C. M. Cooke in his address to the members of the Association makes the following statement, "On account of the whole building on Nuuanu street having been leased to other parties, it becomes necessary for us to remove our laboratory and it is proposed to erect a laboratory building on our lot at Makiki." In December we find this item, "The laboratory of the Sugar Planters' Association has been removed from the Robinson block to the premises of the Experiment Station on Makiki street, near Wilder avenue. Mr. Blouin, successor to Dr. Maxwell, will have an office for the present over the store of F. A. Schaefer & Co. on Merchant street, where he can be found between the hours of 10 and 12 o'clock. It would seem wise to have this arrangement made permanent, or perhaps for three specified days in each week, for the convenience of planters and others seeking advice pertaining to his line of work."

The other item of interest was the visit of Dr. W. C. Stubbs to the Islands during August 1900. Again we quote from President Cooke's address, "During August it was our pleasure to be addressed by Dr. Stubbs, who visited the Islands under instructions of Mr. Wilson, Secretary of Agriculture, at Washington, for the purpose of locating an agricultural experiment station and to study the agricultural possibilities of these Islands. The merging of our experiment station with the proposed one to be established by the Federal Government, after due consideration, was declined, as it seemed the part of wisdom to have the full time of our director devoted to the sugar interests." Dr. Stubbs was entertained extensively during his visit and enjoyed meeting former fellow workers of the Louisiana Sugar School as well as pupils of that institution. Among the former were Dr. Maxwell, Prof. Crawley and Mr. Clarke and of his old students he recalled Shorey, Olding, McQuaide, Pulman, Rodriguez, Collins and Robertson who were all connected with the sugar interests on the various Islands.

The year of 1901 is marked by another change in Directors. The twenty-first Annual meeting of the H.S.P.A. was held in the hall of the Castle & Cooke building. The following is an extract from the address of the president of the

Association, F. A. Schaefer, "Mr. R. E. Blouin was engaged by the trustees to succeed Dr. W. Maxwell as Director of the Laboratory and Experimental Station and made a successful start in his work, visiting also every plantation of these islands and thus making the personal acquaintance of every manager and gaining

Fig. 3. R. E. Blouin, Director, 1900 — 1901.

his information on the spot. I believe that Mr. Blouin did not only make friends for himself among the planters, but proved himself a man of high scientific attainments and of good practical experience which adapted him particularly for the position he was called upon to fill. It was a matter of regret to the trustees therefor to have to accept Mr. Blouin's resignation, necessitated by the latter's protracted illness brought on by climatical causes. Nevertheless Mr. Blouin has sent in an annual report to the members of the Planters' Association which contains much valuable information and careful work and will be perused with interest. A successor to Mr. Blouin will shortly be appointed, but so far the trustees have not taken any decided steps in that direction. The laboratory and experimental station are at present located all together on the Makiki grounds of this Association and I would recommend to the members to visit the station if convenient, as it is of interest to every one directly or indirectly connected with the sugar planting industry. Mr. C. F. Eckart is temporarily in charge of the station and has filled the position satisfactorily. As chairman of the Committee on Fertilization Mr. Eckart has prepared a valuable report to be submitted at this session." Mr. Blouin resigned August 6, 1901.

Fig. 4. Portion of the Experiment Station, H.S.P.A. looking toward Diamond Head. Building at extreme right erected in 1900.

In the report of the Experiment Station Committee for the year ending October 31, 1901 we note the following: "During the last part of 1900, a suitable building was erected on the grounds of the Experiment Station and thoroughly equipped under the direction of Mr. R. E. Blouin, for the execution of all kinds of chemical work. As regards size and arrangement this laboratory has many

advantages over the quarters formerly occupied on Nuuanu street and investigations of a chemical nature have been greatly facilitated." This report was signed by C. F. Eckart, Chairman, J. P. Cooke, W. M. Giffard, and Aug. Ahrens; the remaining member of the Committee, Geo. N. Wilcox, was apparently absent.

In November 1901, Mr. Eckart was appointed Director to succeed Mr. Blouin. Mr. Eckart was a native Californian and attended the University of California. He came to the Islands in 1895 as chemist for the Paauhau Sugar Plantation Company and joined the Experiment Station staff in November 1895 as second assistant chemist. Upon the resignation of Mr. Crawley at the close of 1898 he was made first assistant chemist. The Station staff at the close of 1901 was composed of Mr. Eckart, Director, Mr. Peck, Assistant Chemist, and Mr. Clarke, Field Assistant.

Perhaps it would be well at this time to make a record of the *Experiment Station Committee* first mentioned above as this group had, and still has, a large part in shaping the policies and destiny of the Station. When the Station was inaugurated in 1895 the Director made his reports directly to the Trustees of the Association at the time of the annual meetings. This method was continued from 1896 to 1898. The President of the Association for 1898 was J. B. Atherton and he appointed an Experiment Station Committee composed of Prof. Maxwell, C. B. Wells, F. M. Swanzy and H. P. Baldwin. However, the report for that year was again submitted directly to the Trustees by Dr. Maxwell with no report from the Committee as such. The first official report of the Experiment Station Committee was for the year 1900 and we quote here the first paragraph thereof, "The evident duty of this committee is to lay before the Association an account of all the work of an experimental and analytical character done at the Station during the past year, but as these matters will be comprehensively dealt with by the Director, this committee feels that there is no necessity for it doing more than briefly referring to this work." The report dealt mostly with fertilizers and fertilization and was signed by F. M. Swanzy and H. P. Baldwin with the succinct notation: "Mr. Geo. H. Robertson, the third member of this committee, is ill and confined to his house, so he has not seen this report." A change in policy is indicated by the Experiment Station Committee named for 1902 — C. F. Eckart, Chairman; F. A. Schaefer, F. M. Swanzy, E. E. Paxton, and W. M. Giffard. The Committee in presenting its report at the annual meeting for 1902 had this to say: "The Committee on 'Experimental Station' which reported last year presented an account of the work done at the station during the previous twelve months. Such report should, in the opinion of the present committee, emanate from the director exclusively, as he alone is responsible for and can give an account of the work accomplished. In accordance with this view and at our request the director, Mr. C. F. Eckart, has made a report to us which is subjoined hereto, in which he very fully specifies the character and extent of the work done and the experiments carried out under his supervision, and the committee now reporting does not include him, as was the intention of the president." The Committee then mentioned the work of the Station in a general way, and made a recommendation regarding the need for an additional chemist. This report was signed by Messrs. Swanzy, Schaefer and Giffard, and inaugurated a mode of presenting the work of the Station to the Trustees and membership of the Association that has been continued up to the present. As

Fig. 5. C. F. Eckart, Director, 1901 — 1913.

the Station grew, the scope of the Experiment Station Committee was also expanded until it became the agency for determining the policies and organization of the Station.

By the end of 1903 we find that the Station had increased its staff which now included the director, Mr. Eckart, four chemists, Messrs. Peck, Werthmueller, Jordan, and Thompson, and with the field work still in the hands of Mr. Clarke. There had also been an addition to the laboratory buildings and the Experiment Station Committee for 1903 laments, "It is unfortunate that the area of the Station grounds is so small, as the field experiments have to be restricted much more than is desirable, especially at such times when the necessity arises for fallowing portions of the land."

The year 1904 was a momentous one for the Experiment Station. We find the Station on trial for its very life, but such was the stubborn belief of the majority of the planters in the eventual benefits to be derived by applying science to agriculture that the Station not only survived, but emerged from its tribulations greatly enlarged, not only in number of staff members, but in additional grounds and buildings and scope of research.

According to published records for November 1904, there had been for some time a difference of opinion among some of the managers of the plantations as to the value of the work accomplished by the Experiment Station. Accordingly early in 1904 in order to obtain authentic information, a questionnaire was sent to each plantation requesting an honest opinion as to whether or not the retention of the Station was justified. The results were as follows:

In favor of continuing the Station	26
In favor of abolishing	10
In favor of a Hilo branch	4
No opinion at all	2
Total	42
No replies received	3
Grand Total	45

The President of the Association for the period under discussion was E. D. Tenney. Mr. Tenney appointed as the regular Experiment Station Committee W. M. Giffard, Chairman; Geo. Robertson, Andrew Adams, H. A. Isenberg, J. M. Dowsett, E. E. Paxton, and G. M. Rolph. In addition to the above he appointed a Special Committee of three members to deal with the expansion of the Station. This Special Committee was made up of W. M. Giffard, Chairman; G. M. Rolph and Mr. Tenney. Both Committees worked diligently and succeeded in obtaining many oral and written expressions of opinion regarding ways and means to make the Station of more service to the planters. Finally a well-rounded program was carefully designed, a program that included the following objectives:

1. Establish a Division of Entomology.
2. Establish a Division of Physiology and Pathology.
3. Establish Substations.
4. Employ an Agriculturist.
5. Obtain additional area for the Station.
6. Erect new buildings and purchase new laboratory equipment.

We will now see how the two Committees, by hard work and rare cooperation, executed the objectives named above.

The first record of the sugar planters' financial interest in economic entomology dates back to 1893. During that year, ". . . insect pests and blights of a character heretofore unknown appeared upon plants and trees, and spread so rapidly, and caused such destruction as to arouse serious apprehension." The above quotation continues to the effect that fortunately the pests and blights appeared first in Honolulu where by the vigorous and efficient action of the Bureau of Agriculture and Forestry they were confined to the Island of Oahu. Correspondence was opened with Professor A. Koebele of California, a scientist, who had had large experience in such matters and eventually a proposition was made to the Government to the effect that Professor Koebele be engaged and The Planters' Labor and Supply Company would pay one-half of the expenses. This arrangement was approved by the Government and Professor Koebele entered upon his new duties on November 1, 1893.

In 1900 Dr. R. C. L. Perkins, engaged in entomological work for the British Museum in the Hawaiian Islands, observed and captured a leafhopper, which later was identified as a new species. By 1903 this pest had spread to all the Islands and caused such serious damage that the entire sugar industry was threatened with extinction. This matter was considered of such paramount importance that the Special Committee of 1904 was authorized to form a Division of Entomology at the Experiment Station. Such was the zeal and perseverance of the Special Committee that by the time of the Annual Meeting for 1904 it was, ". . . pleased to report that the Division is now fully established with a competent staff of entomologists, and will soon be in a condition to give practical evidence of its usefulness to plantation interests generally." The original staff of the new Division of Entomology consisted of R. C. L. Perkins, Superintendent; A. Koebele and Alexander Craw, Consulting Entomologists; and G. W. Kirkaldy, F. W. Terry, and Otto H. Swezey, Assistant Entomologists. A detailed history of the Entomology department for the period 1904 to 1945 has been prepared by C. E. Pemberton for early publication in *The Hawaiian Planters' Record.*

Mention of sugar-cane diseases is to be found in the earliest records of the Hawaiian sugar planters. Among the committees appointed for the Hawaiian Sugar Planters' Association for 1896 is one for "Sickness and Insect Enemies of Cane" with M. Marsden, Chairman, and G. Chalmers, Otto Isenberg, W. von Gravemeyer and J. Watt as members. Every year thereafter a Committee on Cane Diseases was appointed until the formation of the Division of Pathology and Physiology in 1905. By 1904 cane diseases presented an extremely serious situation in the Islands. The growth failure of the cane variety Lahaina in many localities was causing serious financial losses and consequently the Trustees authorized the Special Committee of 1904 to organize a Division of Pathology and Physiology at the Experiment Station. The Special Committee immediately entered into lengthy correspondence with many individuals in the United States as well as foreign countries, endeavoring to find an available competent pathologist, but it was not until 1905 that the Division was staffed and ready for operations.

The year 1904 saw the inauguration of substations of the parent Experiment

Station in Honolulu. The reasons for the establishment of substations are ably expressed by President Tenney in his annual report for 1904, "Additional stations are to be established in the different districts for the purpose of conducting agricultural experiments, which will, it is expected, prove of great local value. The conditions in many localities being so radically different from those existing at the central station in Honolulu, it has been the belief of many of you that the experiments carried on here were not particularly beneficial to the plantations as a whole. This departure from the custom of the past will remove this cause of complaint, and it is hoped each manager will take interest in and observe closely the experiments conducted by the branch station in his particular district." Thus by the end of 1904 we find that two substations have been established on the Island of Hawaii, one at Waiakea and the other at Laupahoehoe, ". . . each of these plantations presenting certain problems bearing on the subject of fertilization . . ."

With the establishment of substations, the need for an agriculturist to visit and inspect the work there as well as make plantation inspections was greatly increased. Then, too, there was a dire need for new cane varieties owing to the ravages of cane diseases and insect pests. Accordingly, following the recommendations of the Special Committee, the services of E. G. Clarke as Agriculturist were secured. Mr. Clarke had had over twenty years of experience in agricultural experiment work under Dr. Stubbs of the Louisiana Station, as well as under Dr. Maxwell and Messrs. Blouin and Eckart of the Honolulu station, and on sugar plantations in Louisiana. Along with the appointment of Mr. Clarke as Agriculturist we find the Special Committee has set up the Division of Agriculture and Chemistry with Mr. Eckart as Director, and Chemist; Messrs. Peck, Thompson, Werthmueller and Jordan as Assistant Chemists; Mr. Clarke as Agriculturist, and T. Lougher as Field Foreman. Detailed histories of the Agriculture department and the Chemistry department have been prepared by R. J. Borden and Dr. F. E. Hance for publication in *The Hawaiian Planters' Record*.

In addition to the above, it was decided that, owing to the greatly increased scope of work at the Station, including the new projects in entomology and pathology, it would be more systematic and result in a better understanding between the departments if each were made entirely independent of one another. Consequently we find that the Station is now divided up into three entirely separate divisions, each with its own director and staff. These were: Division of Agriculture and Chemistry, Division of Entomology, and Division of Pathology and Physiology (the latter while authorized in 1904 was not staffed until the following year).

The two remaining projects of the Special Committee for 1904 — to obtain additional area for the Station, and to erect new buildings and purchase new laboratory equipment—were executed with the same enthusiasm and farsightedness as the other projects. With the addition of the Divisions of Entomology, and of Pathology and Physiology, and the new position of an agriculturist, there was immediate need for additional space for buildings and field experiments, particularly for seedling work. The Special Committee investigated many possible sites, including one in Kalihi which was rejected because of the unsuitable soil conditions. A second site near the corner of Kewalo Street and

Wilder Avenue was turned down because a portion of the area was flooded with water to the depth of several feet during the winter months. Palolo Valley was examined for possible sites but the distance from town and lack of transportation made this location unfeasible. A tract of ⅞ of an acre on the corner of Makiki Street and Wilder Avenue was offered for sale but its purchase would mean that the Entomological Division would be on one side of Wilder Avenue and the remainder of the Station on the other. Finally the Committee obtained a verbal option from the Lishman family for a strip of land containing 1.722 acres fronting 150 feet on Makiki Street and 150 feet on Keeaumoku Street, and adjacent to the property already occupied by the Station. The Station at that time was on leased property, a tract of 4.229 acres originally leased from the Dowager-Queen Kapiolani, and upon her death in 1899 leased from the Kapiolani Estate. The Committee's search for a site for the rapidly expanding Station resulted in its recommendation to the Trustees that both the Lishman property and the Kapiolani Estate property be purchased outright. This the Trustees proceeded to do, acquiring the Lishman property on June 24, 1904 and the Kapiolani property on the expiration of their lease on January 31, 1905. The Committee's recommendation included the suggestion that a portion of the Lishman property be used for the Entomological Division and the remainder as additional area for the purpose of carrying on experiments in the production of new varieties of cane. The Trustees also authorized the erection on the Lishman property of offices, laboratories, insect houses, etc., for the use of both the Divisions of Agriculture and Entomology, the laboratories of the chemists remaining where then located on the Kapiolani property site.

The building that was erected in 1904 to house the offices and laboratories of the Agriculture and Entomology Divisions has been in constant use ever since. At that time it was described as being, ". . . equipped in modern fashion, with especial regard to the use to which it is to be put. The rooms are large and are provided with sufficient shelves, drawers, etc., the special bug room and the outdoor cages furnish ample facilities for conducting breeding experiments; and, in fact, almost everything in the way of equipment is present that could be desired". [Today (1945) it is occupied by Dr. Harold L. Lyon, the present Director, the Botany and Forestry Department and the Enzyme laboratory of the Special Research Laboratories.]

Thus we find that, by the end of 1904, the Station is greatly enlarged in staff members, new buildings and grounds, and new equipment. Its problems are many, for the Hawaiian sugar industry is threatened not only by insect pests and growth failure of its standard cane variety, but by the continued low price of sugar.

It is well to quote here an excerpt from retiring President Tenney's address to the members of the H.S.P.A. at their twenty-fourth annual meeting, "The establishment of the station on its present basis has entailed considerable expense in the purchase of new grounds and the erection of buildings. The running expenses from now on will be considerably more than ever heretofore. The amount lost, however, in the past year alone, by the ravages of insect pests, would have paid the cost of establishing fifty stations on the new basis and operating the same for a number of years to come."

During the year 1905 the Division of Pathology and Physiology was staffed

Fig. 6. Building erected in 1904 to house the Agriculture and Entomology departments.

and moved into a new building erected on the Station grounds on Keeaumoku Street, and a plot of ground purchased for experiments. To head the Division, the services of Dr. N. A. Cobb were secured. Dr. Cobb was formerly pathologist for the Department of Agriculture, N.S.W., and came to the Station very highly recommended. A new building was constructed directly in the rear of the main new building constructed in 1904 for the Divisions of Agriculture and of Entomology.

The building was specially designed for the Division and excited much interest in its unusual construction features. It was a wooden building and there seemed to be some trepidation regarding the safety of the specially installed apparatus in case of fire, for the record states, "The main reliance is on the municipal Fire Department, of which there is a well organized branch about an eighth of a mile distant." [The building (considerably enlarged in 1929) is still occupied by the Pathology Department.] A special experimental field of about three-quarters of an acre was purchased at the corner of Alexander and Bingham Streets and a small building on the grounds, formerly a stable and servant's quarters, was fitted up with work rooms. By the close of 1905 the staff of the Division of Pathology and Physiology was headed by Dr. Cobb, Director, with L. Lewton-Brain and M. M. Grosse, assistants. A detailed history of the Pathology department, prepared by J. P. Martin, will be published soon.

Increased interest in substations was evidenced in 1905 by the establishment of 8 cane nurseries for the propagation of seed cane, and 6 substations dealing with agricultural experiments.

The business affairs of the Station had been conducted in a rather haphazard and unsatisfactory manner, so in January 1905 a Business Department was organized with C. H. McBride in charge, and under the general management of Director Eckart.

The need for a staff artist had been discussed for several years, particularly after the formation of the Divisions of Entomology, and Pathology and Physiology. Some illustration work was accomplished by the members of the Divisions and other work was executed by part-time employees. During the latter part of June 1905 the services of E. W. Chambers, late Artist and Engraver of the Department of Agriculture, N.S.W., were engaged. Thus was inaugurated the Illustration department of the Station which has contributed much to the high caliber of its publications.

There were few changes in the personnel of the Station for 1906. We note that on June 1, 1906, the lot on Wilder Avenue of approximately one acre mauka of the main field of the Station was leased for the purpose of growing seedling canes for future distribution, and that the interest in substations and new seedlings was still growing. We do find much of interest, however, in an executive session at the Annual Meeting for 1906. On Thursday, November 22, a meeting was called to be participated in by the active members of the Association, Trustees, Agents and Managers of the different plantations, and the Directors of the three Divisions of the Experiment Station. You will recall that in 1904 a Special Committee for enlarging and supervising the work of the Station was appointed (W. M. Giffard, E. D. Tenney and G. M. Rolph, succeeded by E. E. Paxton in 1906). This Special Committee of 1904 was appointed as the regular Experiment Station Committee for 1905 and 1906 and was virtually in complete

charge of the Station since its appointment. Now, in a letter addressed to the President, Trustees and Members of the H.S.P.A., the Committee requests the frank opinion of the Association on the work of the Experiment Station. We quote in part, "The question has been raised on several occasions as to the practical value of the Experiment Station and whether or not it pays the members of this Association to maintain the institution and operate it upon the present scale. You have heard the report of the Committee upon the work accomplished during the past year. You have visited the Station and have observed the experiments now in progress and have been informed as to proposed future experiments and are familiar with the substation idea. It costs a large sum of money to operate this institution and . . . if the comprehensive plans of the Committee are to be carried out, the future expenditures will hardly be less — in all probability more. It has, therefore, been deemed advisable to submit this statement to you, the Managers, the practical working members of this body, and you are asked to give a free and frank expression of your opinion on the following points: 1st. Have the practical benefits received by you from the experiments and work of the Station, in the past, been sufficient compensation for the expenditure made? 2nd. Do you favor the continuance of the Station on the present lines? 3rd. Do you favor curtailing the work of the Station, or of any division? 4th. Do you think that the work of the Station, or of any department, should be extended? If so, on what lines? . . ." Vice-President Schaefer in charge of the meeting said, "This is a very important subject, and we hope to have a free and full discussion of it. That is the reason why we are in Executive Session, so as to have a free expression of opinion of the subject." The discussion *was* free and resulted in complete justification of the Station and a resolution of thanks of the Association to the Special Committee for its very efficient report and evidence of the work accomplished. The members speaking on the work of the Station were unanimous in their praise, particularly of the work on fertilization, seedlings and leafhopper control. Among those speaking were J. A. Scott, J. T. Moir, John Watt, W. W. Goodale, D. Forbes, H. P. Faye, T. Clive Davies, W. O. Smith, W. G. Walker, and C. M. Cooke. A motion by Mr. Scott to the effect that the Experiment Station be continued on the lines as laid down in the past was seconded by J. N. S. Williams and carried unanimously.

During the year of 1907 we note the following changes in the Station's personnel and activities. Dr. Cobb resigned from his position as Director of the Division of Pathology and Physiology on April 30, and was succeeded by L. Lewton-Brain, his former assistant. Dr. Cobb resigned in order to assume the duties of Chief of the Division of Crop Technology, U.S.D.A. Mr. Lewton-Brain came to the Station in 1905 from Barbados, B.W.I. where he was Mycologist and Lecturer in Agriculture of the Imperial Department of Agriculture for the West Indies.

An event of great importance to the Station in 1907 was the founding of the Library. Heretofore each Division had its own Library and we can be deeply grateful to our early scientists for their untiring perseverance in building up their supply of literature. All through the early records of the Station's activities we find the scientists requesting books and more books. The inconvenience of three separate libraries had been felt keenly, and in May 1907, Mr. Kirkaldy was appointed acting librarian with a boy assistant. The libraries of the three

Divisions were merged and placed in the main building at the Station. Mr. Kirkaldy reports, "The Library is now in order, though there are still many files to complete, and much binding to be done. There are 1250 bound volumes, dealing with Chemistry, Agriculture, Etomology and Plant Pathology, as well as a great number of unbound serials and pamphlets. The Library is open during office hours, and is being used increasingly by members of the staff."

On June 1, 1907, Noel Deerr was appointed assistant Director of the Division of Agriculture and Chemistry. On September 1, 1907, the staff of the Division of Pathology and Physiology was increased by the addition of Dr. Harold L. Lyon, formerly Assistant Professor of Botany in the University of Minnesota. Mr. McBride resigned his position as Business Manager on September 30, 1907 and was succeeded by G. H. Tuttle.

An interesting change in the setup of the Experiment Station Committee occurred in 1907. The Committee appointed for the 1906-07 period was W. M. Giffard, E. D. Tenney and E. E. Paxton. In September of 1907 the Committee of the Experiment Station was increased to seven members, and subcommittees thereof appointed to take charge of the three Divisions of the Station, with the Chairman of the general Committee an ex officio member of each subcommittee. The Committee's report for 1907 was signed by Mr. Tenney as Chairman; G. H. Robertson and G. F. Davies as Subcommittee, Division of Agriculture and Chemistry; W. M. Giffard and W. Pfotenhauer as Subcommittee, Division of Entomology; and E. E. Paxton and R. D. Mead as Subcommittee, Division of Pathology and Physiology. This policy was continued in 1908 and 1909 but abandoned thereafter, and the Committee continued to operate on its original basis. During this period and until 1909 the Director of each Division made his Annual Report to the Committee.

A note of interest on the sugar production of the Islands is contained in the President's annual report for 1908. President F. A. Schaefer in his address to the Association on November 9, 1908, announced that the total tonnage of sugar for the year amounted to more than a half-a-million tons, to be exact, 521,123 tons, an all-time record. We also find recorded that Mr. Chambers resigned from his position as Illustrator in June and his place has been taken by W. W. R. Potter.

For the second time in the history of the Station circumstances made it advisable to make a drastic change in its organization. Heretofore the Staff had been made up of three Divisions — Agriculture and Chemistry, Pathology and Physiology, and Entomology, each Division having its own Director. This system was put into effect in 1904 but by 1909 it had become unwieldy and unsatisfactory and the efficiency of the Station as a whole was seriously impaired by not having a central source of control other than the Experiment Station Committee. The move for centralizing the control of the Station was initiated by the Staff members themselves and the Station Committee was requested to give this matter its attention. This was done, and at a meeting of the Trustees on October 27, 1909, it was voted to approve the recommendations of the Station Committee regarding the reorganization of the work and staff of the Station. Under the new arrangements Mr. Eckart was made Director of the entire Station and the old system of Divisions was abolished. The new organization provided for a Director, Sugar Technologist, Entomologist, Chemist, Agriculturist, Pa-

thologist, Illustrator, Cashier, and suitable assistants. It was the nucleus of the present-day organization, which since has developed and functioned as an aggressive unit, the outstanding successes of which have been largely due to close teamwork.

While the Trustees outlined the duties of the Director and department heads, it is noteworthy that considerable latitude was allowed for the scientists to study research problems on their own initiative. This attitude of the men who controlled the sugar industry of Hawaii in these early days is all the more remarkable when we realize that modern research methods have only recently been applied to many major industries. It is an attitude which still prevails today and is undoubtedly the incentive for many of the outstanding accomplishments of the Station. For instance we note that the Director is to be responsible for the Station work but can "determine the lines along which investigations shall be made." The sugar Technologist is to assist in administrative work but can "especially devote himself to investigations bearing upon manufacturing and mill control." The Entomologist "shall have a free hand so far as the scientific conduct of the Entomological work is concerned." The Director will instruct the Pathologist as to the type of investigations desired, "although naturally the scientific details of such investigations will be left entirely to the Pathologist himself". We list below the personnel of the Station immediately following the 1909 reorganization:

EXPERIMENT STATION STAFF — 1909

C. F. Eckart	Director
R. C. L. Perkins	Entomologist
Noel Deerr	Sugar Technologist
H. L. Lyon	Pathologist
S. S. Peck	Chemist
E. G. Clarke	Agriculturist
G. W. Kirkaldy	Acting Entomologist
A. Koebele	Consulting Entomologist
R. S. Norris	Assistant Chemist
F. R. Werthmueller	Assistant Chemist
A. E. Jordan	Assistant Chemist
F. W. Terry	Assistant Entomologist
Otto H. Swezey	Assistant Entomologist
F. Muir	Assistant Entomologist
L. D. Larsen	Assistant Pathologist
J. H. Wale	Assistant Agriculturist
D. C. Broderick	Field Foreman
G. H. Tuttle	Cashier
W. R. R. Potter	Illustrator
A. Warren	Clerk
J. F. Melanphy	Fertilizer Sampler

Mr. Eckart was now Director of the entire five major departments of the Station; Dr. Perkins was the Entomologist instead of Director of the Division of Entomology; Mr. Lewton-Brain had left the employ of the Station and Dr. Lyon had been appointed Pathologist; Mr. Deerr was Sugar Technologist instead of Assistant Director of the Agricultural and Chemistry Division; Mr. Peck had been promoted from Assistant Chemist to Chemist; and Mr. Clarke was Agriculturist.

Fig. 7. Scientific Staff of the Experiment Station — 1910. Front Row — left to right: A. Warren, W. J. Hartung, A. E. Jordan, L. D. Larsen, J. H. Wale. Second Row: R. S. Norris, G. H. Tuttle, R. C. L. Perkins, C. F. Eckart, Noel Deerr, F. W. Terry. Third Row: E. G. Clarke, D. C. Broderick, O. H. Swezey, J. F. Melanphy, E. M. Ehrhorn (visitor), H. L. Lyon, S. S. Peck, W. R. R. Potter, F. R. Werthmueller.

The year 1909 might well be named as the beginning date of the Sugar Technology department. Although the Station's work on sugar manufacture started with Dr. Maxwell's arrival (one of his first reports in 1895 was on fermentation losses in the sugar factory), and considerable work had been done in the meantime on sugar analysis and related problems by Mr. Eckart and his associate chemists, nevertheless the appointment of Mr. Deerr as Sugar Technologist was the first recognition of chemical mill control as a separate unit from the Agricultural and Chemistry Division. W. L. McCleery has prepared a history of the activities of the Sugar Technology Department which will be published soon.

President S. M. Damon in his address at the twenty-ninth Annual Meeting on November 15, 1909 in speaking of the Experiment Station mentions that a new feature of its educational propaganda is the publication of a monthly paper to circulate among the individuals or corporations directly connected with the Association. Thus in July 1909, *The Hawaiian Planters' Record* made its appearance in the field of periodicals devoted to technical developments in the sugar industry. Prior to this first issue of the *Record* the scientific papers of the Station had been published in *The Planters' Monthly*, a subscription periodical that was partly subsidized by the H.S.P.A. The purpose of the new publication was ably presented on the first page of the July issue: "In making this venture through the editorial guidance of the Experiment Station, the Association does not attempt or desire to substitute a local journal of private circulation for the more widely distributed subscription periodicals of the present day, in which matters of popular and technical interest to the planter and sugar manufacturer are presented in a more general form. The object of the *Record*, on the contrary, is to supplement the subject matter of the usual current literature with information of special local importance and at the same time to publish in the shape of abstracts or digests such articles appearing in the general sugar press as may prove of value in promoting the interests of our local sugar industry."

There were no changes of importance at the Station during 1910. The Station Committee in its annual report recommends that a new substantial building be erected for the chemists and that additional land be acquired near a plantation on Oahu for spreading new cane varieties and conducting field experiments on a larger scale than was possible at the Makiki Station.

One of the important events of 1911 was the starting of the Waipio Substation. Authorization by the Trustees of this development was the result of the Experiment Station Committee's recommendation of 1910. One hundred forty-five acres were leased from Oahu Sugar Company, one-half of which were to be taken over by the Station for experimental purposes in the early part of 1912 and the remainder in 1914. A site, for buildings, immediately below the Oahu Sugar Company lands was leased from the John Ii Estate and construction work was to be commenced about December 1, 1911. F. S. Rutledge took up his duties as Substation Superintendent on October 15, 1911.

A new reinforced concrete building for the Chemistry laboratories was authorized early in 1911. Construction work was started on July 17 and the building was completed and ready for occupancy early in 1912.

Following the resignation of Mr. Evans as Agriculturist in May 1911, H. P. Agee was appointed to that position on June 1, 1911. Mr. Agee was born in

Fig. 8. H. P. Agee, Director, 1913 — 1935.

Memphis, Tennessee and was educated in the public and private schools of Memphis and Little Rock, Arkansas, and at the Louisiana State University where he received his bachelor of science degree in 1904. From 1904 to 1909 he held various positions in the sugar industry in Cuba and Puerto Rico, and from 1909 and up to the time he left for Hawaii in 1911 he was assistant director of the Louisiana Sugar Experiment Station.

In May 1913, Mr. Eckart tendered his resignation as Director of the Experiment Station, to take effect early in June. The resignation was accepted with regret by the Trustees and a letter of appreciation was given Mr. Eckart which read in part, "While the direction of affairs at the Station has been in your hands you have made its interests yours, and identified yourself wholeheartedly with the development and prosperity of the Sugar Industry in these Islands. The place you leave will not be easily filled, but in losing your services it is some satisfaction to know that they will not be entirely lost to Hawaii." Mr. Eckart left the Station to accept the managership of Olaa Sugar Company.

To succeed Mr. Eckart as Director, the Trustees approved the recommendation of the Station Committee that Mr. Agee, Agriculturist, be appointed. According to the Committee Mr. Agee was very well qualified to undertake the work, not only from a large breadth of previous experience and his general attainments, but for his personality and willingness to cooperate with the plantation managers. Mr. Agee assumed the duties of Director on June 7, 1913.

Mr. Tuttle, Cashier, resigned at the end of February 1914, to accept a position with the accounting department of the H.S.P.A. and H.B. Campbell, Mr. Tuttle's assistant, was appointed as Business Agent on March 1, 1914.

An event of importance in the Station's history was the inauguration of the Project File system in 1915. In Mr. Agee's annual report for 1915 we find he has the following to say about the new system: "The year 1915 is the twentieth year of the Experiment Station of the Hawaiian Sugar Planters' Association. It is a fitting time to review the work that has been done, and to look forward to the work that may be accomplished. This we are doing in a detailed and systematic manner by taking all the data and information which has been accumulated in past years and segregating it in files — each file being a unit or project pertaining to some subject or some detailed phase of sugar production or sugar manufacture. This not only places all of our data on a ready reference basis, but offers a foundation for filing future information in a way that makes it accessible to all members of the Station staff and also to accredited representatives of the plantations or their agencies. Furthermore, it enables us to gauge the comparative values of different units of work, to proceed with the more important ones, and to return to those which are tabled temporarily, finding all records of the previous work intact. This is an adaptation of the so-called project system, recently devised for handling the investigations of the U. S. Department of Agriculture."

The Project Files, now housed in the Library and kept up to date by the Librarian, are invaluable to the Station. They are consulted daily by the members of the staff and are used extensively by other research workers on subjects not considered confidential to the sugar industry.

On September 22, 1916, the Trustees completed the purchase of an additional area of land from the Lishman Estate amounting to 1.354 acres. This area

adjoined the makai side of the Station grounds on Makiki Street and was purchased primarily for expansion of the seedling work.

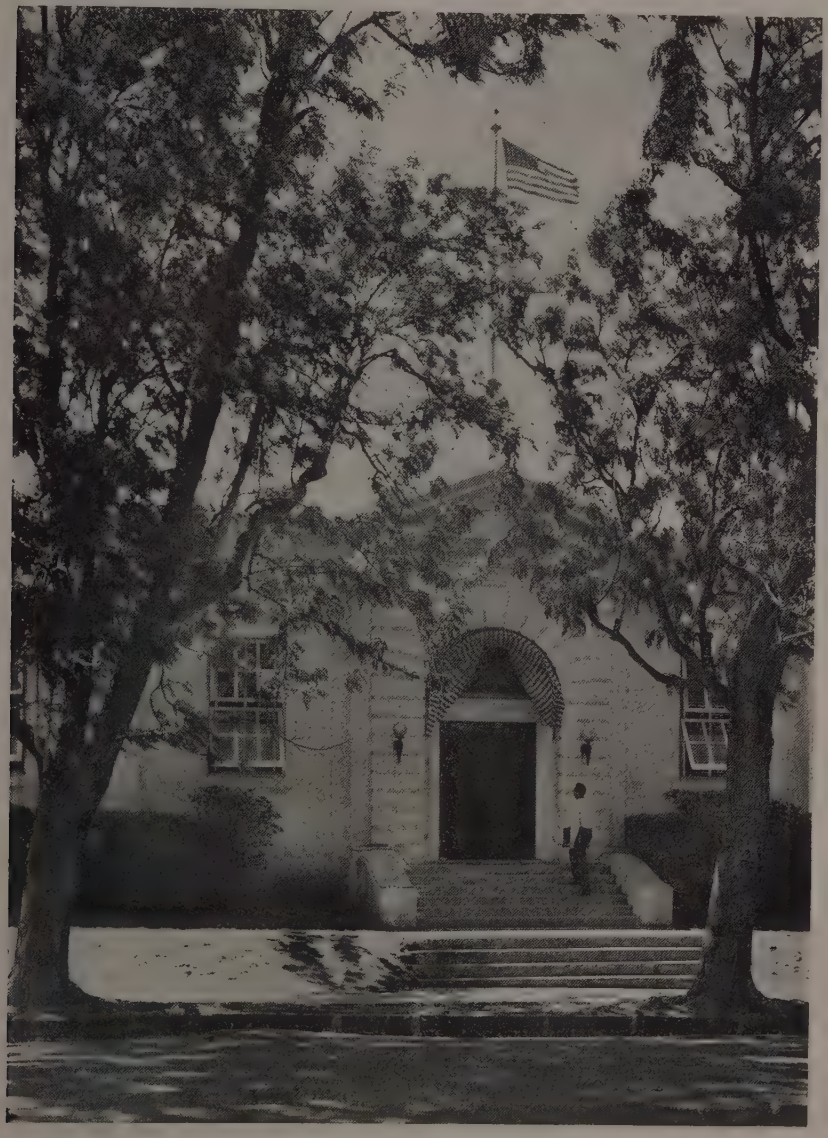

Fig. 9. Front view of the Administration building of the Experiment Station — erected 1917.

With the work of the Station increasing every year and the pressing need for space for the accommodation of the Library and entomological collection and the increased staff, plans were approved and a contract let for a fireproof building to provide the much-needed additional room. The building was erected in front

of the then main building, the contract being let in 1916 and the building completed in 1917. It was occupied by the Director's Office, the Entomological department, Agricultural department, Library, and Business Office. Aside from relieving the very overcrowded condition of the old building, the valuable records of the Station, the entomological collections which had been secured through foreign explorations, and the extensive technical library comprising approximately 3,500 volumes, were now afforded the fire protection which their importance merited.

World War I (1917-1918) found Hawaii sharing with all American communities the trials and tribulations inherent to world-wide conflict. Mr. Tenney in his presidential address at the thirty-seventh annual meeting of the H.S.P.A. says, "With the world aflame, and the entry of the United States into the war, we are and will be confronted with new and perplexing problems which will be difficult of solution, and may call for the exercise of a high degree of patriotism and great material sacrifice. We must bear these burdens with a spirit of determination and without undue criticism of those officials upon whom has fallen the duty of imposing them upon us, and upon whose shoulders rests the responsibility of the successful prosecution of the war." By the time the above-mentioned annual meeting was held, the scientific staff of the Station had been reduced from twenty-seven to seventeen by volunteer enlistments in the Army and Navy. The United States entered World War I on April 6, 1917, and by the end of that month the Station had drawn plans for increased food production on the plantations and had cooperated with other scientific institutions in the Islands on a program of similar nature. The June 1917 number of *The Hawaiian Planters' Record* was devoted entirely to food, not only to its production, but its preparation and cooking and its value to humans and live stock. The Food Number of the *Record*, as this comprehensive issue of 115 pages was called, contained contributions not only by the Station Staff members, but by plantation personnel, and scientists of other Island institutions. Its popularity is attested by the fact that many hundreds of extra copies were printed and distributed to the Hawaiian Food Commission and other interested concerns and individuals.

The following members of the Experiment Station served in either the Army or Navy during World War One: H. T. Osborn (Assistant Entomologist), Geo. Hutchinson (Assistant Chemist), W. P. Alexander (Assistant Agriculturist), L. T. Lyman (Assistant Agriculturist), R. E. Doty (Assistant Agriculturist), L. L. Lynch (Assistant Chemist), J. S. B. Pratt, Jr. (Assistant Agriculturist), E. M. Brown (Assistant Chemist), D. A. Meek (Stenographer), F. O. Biven (Office Assistant), W. J. Bryant (Office Assistant), Thos. Hore (Office Assistant), Robert Nelson (Office Assistant), and Albert C. Fong (Chemist's Assistant). In addition, Mr. Muir was engaged in work connected with the manufacture of munitions and production of food in England for about a year.

In January 1917, the first issue of the *Director's Monthly Report* appeared. The first "Monthly Letter", its more familiar name, was addressed by the Director (Agee) to the Chairman of the Experiment Station Committee (J. F. C. Hagens), and outlined new experiments and gave the progress on projects then under consideration. It contained information on "Propagation of New Varieties", "Anomala Parasites", "Soil Investigations", "Factory Inspections", "Experiments on Exhausted Molasses", "Pineapple Work", and "Cane Dis-

eases". The first issues of the "Monthly Letter" were intended for the members of the Experiment Station Committee only, but later in the year orders were given to have the "Monthly Letters" printed and mailed to the personnel of the plantations and agencies.

The year 1918 marked the formation of a new department at the Station, that of Botany and Forestry. Mr. Agee in his annual report for 1918 has this to say about the new department: "The organization for work in forestry results from a resolution on the part of the Trustees of the Association following an able presentation of the subject by Mr. W. M. Giffard, pointing out the necessity of protecting and improving the watersheds upon which the sugar plantations are dependent. The trustees indorsed forestry work along the general lines advocated by Mr. Giffard and this led to your authorizing the Experiment Station to organize a forestry department. This work is headed by Dr. H. L. Lyon, who has for years made a study of the forestry requirements of the Islands. The former department of Pathology is amalgamated with the new branch now termed the department of Forestry and Botany. Competent assistants for Dr. Lyon will be engaged." [A comprehensive and illustrated history of the department of Botany and Forestry, by Dr. Lyon, will be found in *The Hawaiian Planters' Record*, Vol. 33, 1929, entitled "Ten Years in Hawaiian Forestry."]

During the war period the activities of the Station were severely handicapped, mostly owing to a lack of personnel, making it difficult to carry out the routine work of the departments and leaving no time available for new projects. Consequently, early in 1919 Director Agee requested the Station Committee to undertake the post-war reorganization of the Station's program of work in order to serve better the needs of the sugar industry. This matter was given careful attention by the Committee, the Director, and the Department heads and finally a comprehensive program of work was drawn up for each department, and we find the principal activities, in brief, to have been:

Entomology: Resumption of foreign work for additional natural enemies of the leafhopper.

Botany and Forestry: Forestry work, particularly between Kohala and Hilo; establishment of nurseries and stations on all islands; work on Lahaina disease and other diseases such as Yellow Stripe and Pahala Blight; and pineapple work in accordance with our contract with the Hawaiian Pineapple Packers' Association.

Chemistry: Fertilizer control work, analytical work as needed by the plantations; soil surveys; and research work on Hawaiian soils.

Sugar Technology: Mill inspections requested by plantations, compilation of mill data, miscellaneous analyses and calibration of apparatus, and laboratory investigations on mill operations.

Agriculture: Increased plantation field experimentation on fertilization, cultivation, irrigation, etc., and extension of seedling work.

Another item of importance in 1919 was the adoption of the "Budget System" for handling the financial affairs of the Station. Heretofore the Station had operated on a month-to-month basis, a system that worked well enough when the Station was small but which was proving most unsatisfactory as the Station expanded. Upon the recommendation of the Station Committee, the Trustees

approved the yearly budget system for the Station on July 9, 1919, and it was immediately found to be entirely suitable and satisfactory, being far more flexible than the old system and allowing the Committee and Director more leeway in conducting the financial affairs of the Station.

By the end of 1919 the Station Staff was as follows:

EXPERIMENT STATION STAFF—1919

H. P. Agee ..... Director
R. C. L. Perkins ..... Consulting Entomologist
Otto H. Swezey ..... Entomologist
F. Muir ..... Entomologist
H. T. Osborn ..... Assistant Entomologist
P. H. Timberlake ..... Assistant Entomologist
F. X. Williams ..... Assistant Entomologist
C. E. Pemberton ..... Assistant Entomologist

H. L. Lyon ..... Botany and Forestry, in charge
C. W. Carpenter ..... Associate Pathologist
E. L. Caum ..... Assistant Pathologist
R. E. Doty ..... Assistant in Cane Diseases
Adolf Holm ..... Supt. Forest Nurseries
E. J. Mooklar ..... Asst. in Pineapple Investigations
M. L. Hartmann ..... Asst. in Pineapple Investigations

R. S. Norris ..... Sugar Technologist
W. R. McAllep ..... Acting Sugar Technologist
A. Brodie ..... Assistant Chemist
F. R. Werthmueller ..... Assistant Chemist
L. L. Lynch ..... Assistant Chemist
C. E. Warriner ..... Assistant Chemist
H. A. Wilson ..... Assistant Chemist
J. F. Melanphy ..... Fertilizer Sampler

J. A. Verret ..... Agriculturist
R. S. Thurston ..... Associate Agriculturist
R. M. Allen ..... Assistant Agriculturist
Y. Kutsunai ..... Assistant Agriculturist
W. L. S. Williams ..... Assistant Agriculturist
W. W. G. Moir ..... Assistant Agriculturist

W. R. R. Potter ..... Illustrator

W. P. Alexander ..... Assistant to Director

D. A. Meek ..... Chief Clerk

We note that nine men have returned to the Station following the expiration of their term of service in the Army and Navy, and Mr. Muir has returned from his war work in England. Upon the resignation of Mr. Campbell, the position of Business Agent was abolished and Mr. Alexander as Assistant to the Director assumed part of Mr. Campbell's work, particularly the preparation of publications, and Mr. Meek was appointed as Chief Clerk in Charge of the Business Office. During the year two additional pieces of property were acquired for the Station's use — a lease on 1.9 acres of land on Vineyard Street for a central

nursery for propagating forest trees, and by purchase of 112.75 acres at the head of Manoa Valley, extending from an elevation of 400 feet to the crest of the Tantalus ridge, 1,400 to 1,900 feet. Part of the Manoa Substation, as it was named, was to be utilized by the Agriculture department for seedling work and the remainder for forestry projects.

The early twenties were turbulent years for the Hawaiian sugar industry. The unprecedented and abnormal condition of the sugar market had much to do with the ups and downs that were experienced by the Hawaiian sugar plantations, so much so that John Waterhouse, President of the Association for 1920 stated that "Spectacular" and "Ruinous" seemed to be the only words to use in describing the market conditions of that year. During the period from January 1, 1920 to December 31, 1922 the price of raw sugar ranged from a high of $471.40 to a low of $70.90 per ton. This period of unrest was noticeable in the operation of the Station for the status quo ranged from earnest endeavors at expansion to sharp curtailment of expenses. Droughts on Maui and Hawaii, labor strikes and labor shortage added their quota to a complicated situation but by the end of 1922 we find that there had been very few changes in the Station staff. Mr. Potter, Illustrator, resigned in April 1922, and there were but few changes in the personnel of the other departments. Starting with the first number of 1922, *The Hawaiian Planters' Record* was changed from a monthly to a quarterly publication.

The department of Pathology, which became a branch of the department of Botany and Forestry when that department was created in 1918, was, in July 1923, re-established as a separate department with H. A. Lee as the head. The main objective in this change was to allow Dr. Lyon to devote more of his time to the rapidly expanding forestry work on the Islands.

In the budget for 1923 we find the position of Librarian listed for the first time as a distinct position. The Library as a unit of the Station was established in 1907 with Mr. Kirkaldy as acting Librarian, but since that time it had been cared for and served by the various stenographers in the Business Office. With the appointment of Mabel Fraser as Librarian, the Library began to expand, not only in the number of volumes on the shelves but in the availability of the reading material needed by the staff members. Miss Fraser, a graduate of the University of Washington with an A.B. degree, joined the Station staff May 15, 1922.

The position of Illustrator had not been filled since the resignation of Mr. Potter in 1922. Wm. Twigg-Smith was employed on a part-time basis starting in January 1923, and on September 1, he was appointed as Illustrator. Mr. Twigg-Smith immediately took up the study of the Jeswiet identification characters of cane varieties, a system of positively identifying any seedlings by the minute and almost microscopic hair groups of the buds and certain leaf areas.

We also note a departure in the methods of the past in reporting the work of the Experiment Station in the annual report. Heretofore the Director made the annual report in full, extracting from the reports of the department heads, items of more general interest. In the Annual Report for the year 1923, the reports of the individual department heads appear intact under their names with the Director writing a resume of the more important items to precede the departmental reports.

On January 1, 1924 the Station staff was as follows:

EXPERIMENT STATION STAFF — 1924

H. P. Agee ..... Director
R. C. L. Perkins ..... Consulting Entomologist
Otto H. Swezey ..... Entomologist
F. Muir ..... Entomologist
C. E. Pemberton ..... Associate Entomologist
H. T. Osborn ..... Assistant Entomologist
P. H. Timberlake ..... Assistant Entomologist
F. X. Williams ..... Assistant Entomologist

H. L. Lyon ..... Botany and Forestry, in charge
Geo. A. McEldowney ..... Forest Supervisor, Oahu
L. W. Bryan ..... Forest Supervisor, Hilo
Donald Forbes ..... Supt. Vineyard St. Nursery

W. R. McAllep ..... Sugar Technologist
W. L. McCleery ..... Assistant Sugar Technologist
A. Brodie ..... Technical Chemist
H. A. Cook ..... Assistant Chemist
Walter E. Smith ..... Assistant Chemist
Reginald H. King ..... Assistant Chemist

Guy R. Stewart ..... Chemist
W. T. McGeorge ..... Associate Chemist
E. C. Thomas ..... Assistant Chemist
Fred Hansson ..... Assistant Chemist
C. L. Crutchfield ..... Assistant Chemist
F. Ray Van Brocklin ..... Assistant Chemist

J. A. Verret ..... Agriculturist
F. A. Paris ..... Associate Agriculturist
Y. Kutsunai ..... Assistant Agriculturist
H. K. Stender ..... Assistant Agriculturist
W. C. Jennings ..... Assistant Agriculturist
O. C. Markwell ..... Assistant Agriculturist
Frank W. Broadbent ..... Assistant Agriculturist
Neil Webster ..... Assistant Agriculturist
Raymond Conant ..... Assistant Agriculturist

H. Atherton Lee ..... Pathologist

W. Twigg-Smith ..... Illustrator

D. A. Meek ..... Chief Clerk
Mabel Fraser ..... Librarian

The years 1924-1932 covered a period of slow but steady increase in the Station's staff and activities. A new laboratory building to house the Sugar Technology department was authorized in 1924 and ready for occupancy in 1925. This was a two-story and basement fireproof building and is still today the most modern laboratory building on the Station grounds.

In 1925 the Experiment Station passed its thirtieth birthday and the plantations of the Association celebrated this event by producing the largest sugar

crop in the history of the Islands. This was the first time that the sugar production in the Islands passed the three-quarter of a million-ton mark—a total of 776,072 tons. The exceptionally large crops of both 1924 and 1925 were considered by Mr. Agee to have been influenced by each of the following technical considerations, coupled as they were with good weather, good management, and an adequate labor supply: Better control of the leafhopper; greater area in the varieties H 109, D 1135, and Yellow Tip; better control of mosaic disease through the use of healthy seed cane; better viability of seed cane through more careful selection; better control of the field rat by chemical poisons; progress in conservation and more careful use of irrigation water; increased use of nitrogenous fertilizers and of phosphoric acid and potash where needed, and better timing in their application; better coordination of field practices; and steady progress in improving methods of factory operation and chemical control.

With the employment of Dr. A. J. Mangelsdorf in 1926 as Geneticist attached to the Agriculture department the work in cane breeding received a powerful impetus. In 1927 an area in the Kailua section of windward Oahu was leased for the purpose of growing breeding canes and for testing the newly propagated seedlings. In 1929 a cane quarantine station was located on the Island of Molokai to take care of newly introduced cane varieties. These new canes are subjected to a rigid quarantine for a period of two years as an absolutely necessary precaution to prevent the entrance into Hawaii of dangerous insect pests and cane diseases. The quarantine facilities on Molokai were strengthened in 1930 by the purchase of a tract of land, Mapulehu, where a large greenhouse was erected to be devoted primarily to the propagation of seedlings from seed-bearing fuzz or tassels which were to be pollinated abroad so as to furnish desired crosses. With the Kailua Variety Station, the Molokai Quarantine Station, plus the facilities available at Makiki, Waipio and various substations on the outlying Islands, the Station was in a better position for cane-breeding work than at any time previous. For a history of early seedling work in the Hawaiian Islands see "Sugar-Cane Breeding in Hawaii — Part I — 1778-1920" by Dr. Mangelsdorf, published in *The Hawaiian Planters' Record*, Volume 50, Nos. 3 and 4, 1946. A later history covering the period 1921 to date will be published soon in *The Hawaiian Planters' Record* by Dr. Mangelsdorf.

In 1931 a new building of wood construction was completed on the Station grounds, primarily to house the Agriculture department and part of the Chemistry department.

The year 1932 marked the occasion of the Hawaiian Islands first producing over a million tons of sugar. It is interesting at this time to delve into the past and review an experiment in crystal-ball gazing that took place probably in 1882-83. A pamphlet entitled "The Sugar Producing Capacity of the Hawaiian Islands" was reproduced in the *Planters' Monthly* for April 1884. In 1882 the sugar production of the Islands was 57,089 tons of raw sugar from approximately 23,500 acres. The prophetic author of this highly entertaining but far from accurate pamphlet apparently took a hasty plunge into the future and came up with the following statements: "Maximum Possible Acreage Which Can Be Annually Cropped — 34,200 acres" and "Maximum Possible Yield of Sugar — 84,000 tons". The editor of the *Monthly* also went overboard with comment to the effect that, "These statements and estimates have been made up by a gentle-

man thoroughly conversant with the subject and are reliable, and we hope that more copies will be sent to us for distribution as accurate information and statistics are always valuable." For the fiscal year October 1, 1931 to September 30, 1932,— 139,743 acres were harvested, producing 1,025,354 short tons of sugar. So much for prophesy!

However, in spite of Hawaii's record breaking sugar crop, the outlook for the sugar industry was anything but encouraging. During the period under review, the price of sugar fell to a new all-time low record — on May 31, 1932, it dropped to 2.57 cents, the lowest price ever recorded in the history of sugar on the New York market.

The prevailing low price of sugar inevitably materially affected the policies and organization of the Experiment Station. Perhaps it would be well to show here now the Station staff as at the end of 1932 and then record the why and wherefore of the many changes that took place in 1933 and 1934.

EXPERIMENT STATION STAFF — 1932

H. P. Agee ..... Director
R. C. L. Perkins ..... Consulting Entomologist
Otto H. Swezey ..... Consulting Entomologist
C. E. Pemberton ..... Executive Entomologist
F. X. Williams ..... Associate Entomologist
R. H. Van Zwaluwenburg ..... Associate Entomologist
F. C. Hadden ..... Assistant Entomologist
Fred A. Bianchi ..... Assistant Entomologist

H. L. Lyon ..... Botany and Forestry, in charge
L. W. Bryan ..... Forest Supervisor, Hawaii
George A. McEldowney ..... Forest Supervisor, Oahu
Albert Duvel ..... Forest Supervisor, Kauai
E. L. Caum ..... Assistant Botanist
Joseph E. Wist ..... Supt. Vineyard St. Nursery
Hugh W. Brodie ..... Research Assistant
Colin Potter ..... Assistant in Forestry

W. R. McAllep ..... Sugar Technologist
W. L. McCleery ..... Associate Sugar Technologist
Raymond Elliott ..... Assistant Sugar Technologist
A. Brodie ..... Technical Chemist
H. A. Cook ..... Associate Chemist
H. F. Bomonti ..... Associate Chemist
Fred Hansson ..... Associate Chemist
J. H. Pratt ..... Assistant Chemist
Courtland Ashton ..... Assistant Chemist
Ward S. Fleshman ..... Assistant Chemist in Training

F. E. Hance ..... Chemist
L. E. Davis ..... Associate Chemist
F. Ray Van Brocklin ..... Associate Chemist
Carl W. Nesbitt ..... Associate Chemist
Arthur Ayers ..... Assistant Chemist
Ritchie W. Ward ..... Assistant Chemist
Harlan M. Shepardson ..... Assistant Chemist
Paul Gow ..... Assistant Chemist

J. A. Verret ..... Consulting Agriculturist
A. J. Mangelsdorf ..... Geneticist
Y. Kutsunai ..... Assistant Agriculturist
F. C. Denison ..... Assistant Agriculturist
H. K. Stender ..... Assistant Agriculturist
R. E. Doty ..... Assistant Agriculturist
Royden Bryan ..... Assistant Agriculturist (Hawaii)
O. H. Lyman ..... Assistant Agriculturist (Maui)
J. N. P. Webster ..... Assistant Agriculturist (Kauai)
A. H. Cornelison ..... Assistant Agriculturist
Colin G. Lennox ..... Assistant Geneticist
U. K. Das ..... Plant Physiologist
Douglas A. Cooke ..... Plant Physiologist

H. L. Lyon ..... Consulting Pathologist
J. P. Martin ..... Pathologist
Clyde C. Barnum ..... Associate Pathologist
C. W. Carpenter ..... Asscciate Pathologist
D. M. Weller ..... Histologist

W. Twigg-Smith ..... Illustrator
Darrell Meek ..... Chief Clerk
Mabel Fraser ..... Librarian

Early in 1933 the Station began to feel the pinch of economic pressure. Three Special Economy Committees were appointed as subcommittees of the regular Station Committee to consider ways and means by which the expenditures of the Station could be curtailed without seriously impairing its efficiency, and at the same time adopt certain policies that would strengthen the institution and make it better able to meet the requirements of the industry. All Committees worked diligently and by July 21, 1933, presented a program of economies to the Trustees of the Association which was adopted in August of the same year. Salaries and staffs were reduced, substation work curtailed, the number of seedlings propagated each year lowered, Manoa substation discontinued as a cane breeding area, Molokai station placed on a caretaking basis, and the Vineyard Street nursery abandoned. All this was not accomplished immediately, but was gradually put into effect during the years of 1933 and 1934. Changes in policy included a listing of the services that the Station was to perform for the plantations gratis, mostly those that came within the scope of an accredited research project, and a listing of the charges the various Station departments were to make to the plantations for services rendered that were not considered a strictly research project. The organization of the Station was somewhat altered and we note the following changes: The Botany and Forestry department again absorbed the Pathology department and was now known as the Botany, Forestry and Pathology department; the work in cane breeding was separated from the Agriculture department and the Genetics department was formed with Dr. Mangelsdorf in charge; the Fertilizer Audit and Control work was set up independently from the Chemistry department but entirely under its supervision; the Library was established as a separate unit from the Business Office; and the Makiki Plots were separated from the Agriculture department. A departure from the usual method of listing the personnel and projects of the departments was noted in the 1934 budget. A "Special Research" project was listed inde-

pendently — that of "Weather Studies", with Dr. U. K. Das as the research assistant. "Weather Studies" was independent from any of the regular departments and was directly under the supervision of the Director. This was the beginning of a series of Special Research projects designed to carry out specific lines of investigations, operating as separate units under the leadership of the Director, but cooperating with all interested departments.

All in all the Station weathered the economic depression in fair shape and by January 1935 we find the Station staff somewhat depleted but well organized to carry on its work.

EXPERIMENT STATION STAFF — 1935

H. P. Agee ..... Director
R. C. L. Perkins ..... Consulting Entomologist
Otto H. Swezey ..... Consulting Entomologist
C. E. Pemberton ..... Executive Entomologist
F. X. Williams ..... Associate Entomologist
R. H. Van Zwaluwenburg ..... Associate Entomologist
Fred A. Bianchi ..... Assistant Entomologist

H. L. Lyon ..... Botany, Forestry and Pathology, in charge
J. P. Martin ..... Pathologist
C. W. Carpenter ..... Associate Pathologist
D. M. Weller ..... Histologist
L. W. Bryan ..... Forest Supervisor (Hawaii)
George A. McEldowney ..... Forest Supervisor (Oahu)
Albert Duvel ..... Forest Supervisor (Kauai)
E. L. Caum ..... Assistant Botanist
Hugh W. Brodie ..... Research Assistant
Colin Potter ..... Assistant in Forestry

W. R. McAllep ..... Consulting Sugar Technologist
W. L. McCleery ..... Acting Sugar Technologist
Raymond Elliott ..... Assistant Sugar Technologist
A. Brodie ..... Consulting Technical Chemist
H. A. Cook ..... Associate Chemist
Fred Hansson ..... Associate Chemist
Courtland Ashton ..... Assistant Chemist
Ward S. Fleshman ..... Assistant Chemist

F. E. Hance ..... Chemist
L. E. Davis ..... Associate Chemist
F. R. Van Brocklin ..... Associate Chemist
Arthur Ayers ..... Assistant Chemist
Paul Gow ..... Assistant Chemist

J. A. Verret ..... Consulting Agriculturist
A. J. Mangelsdorf ..... Geneticist
Colin G. Lennox ..... Associate Geneticist
H. K. Stender ..... In Charge Kailua Variety Station

R. J. Borden ..... Agriculturist
R. E. Doty ..... Associate Agriculturist
Douglas A. Cooke ..... Plant Physiologist
F. C. Denison ..... Island Representative (Oahu)
O. H. Lyman ..... Island Representative (Maui)
Slator M. Miller ..... Island Representative (Hawaii)
C. C. Barnum ..... Island Representative (Kauai)

A. H. Cornelison ..... Supervisor Fertilizer Control
U. K. Das ..... Research Asst., Director's Office
W. Twigg-Smith ..... Illustrator
A. R. Grammer ..... Chief Clerk
Mabel Fraser ..... Librarian

The many important events of the past few years had served to obscure to some extent the fact that the sugar industry of Hawaii was due for two anniversaries of more than passing interest. The year 1935 marked the one hundredth anniversary of the founding of the first successful sugar plantation in Hawaii, that of Ladd & Co., at Koloa, Kauai, that has since become the Koloa Sugar Company, and also the fortieth anniversary of the founding of the Experiment Station. In recognition of these two events, the Station prepared a large chart in oil colors depicting by means of illustrations and annotations a "Century of Progress" in sugar production in the Hawaiian Islands.

On December 31, 1935, Mr. Agee resigned as Director of the Experiment Station to take a position as Consulting Agriculturist with Castle and Cooke, Ltd., and the Hawaiian Pineapple Company, Ltd. Mr. Agee came to the Station June 1, 1911, as Agriculturist and was appointed Director on June 7, 1913, upon the resignation of Mr. Eckart. The Station made much progress under the leadership of Mr. Agee and while his loss to the Station was keenly regretted, it was tempered by the knowledge that his connection with the sugar industry was still unbroken.

On January 1, 1936, Dr. Lyon succeeded Mr. Agee as Director. Dr. Lyon is a graduate of the University of Minnesota, received his B.S. degree there in 1900, M.S. in 1901 and Ph.D. in 1903. He was instructor in botany at Minnesota from 1900 to 1905 and Assistant Professor from 1905 to 1907. On September 1, 1907, he joined the Experiment Station staff as Assistant Pathologist and was appointed Pathologist October 1, 1909. In 1918 he was appointed head of the newly created Botany and Forestry department which included the Pathology department.

Several changes were made in the organization of the Station in 1936. The Pathology department was separated from the Botany and Forestry department and again made a departmental unit of the Station, and the "Special Research" project on weather studies was combined with two new projects to form the "Interdepartmental Research Laboratories" designed to investigate special research problems. The Research Laboratories now included "Weather and Cane Growth Studies" with U. K. Das, Research Associate; "Photosynthesis and Enzyme Studies" with Dr. Constance E. Hartt, Research Associate, and "Molasses Investigations" with Dr. A. R. Lamb, Research Associate.

On April 11, 1936, the Station acquired 1.516 acres of land immediately adjoining the Station property on Keeaumoku Street from the Lishman Estate. This purchase "rounded out" the Station's grounds on Wilder Avenue, Makiki and Keeaumoku Streets. The new area was immediately cleared and a portion of the land planted with cane for a fertilizer experiment. The existing buildings on the newly acquired property were utilized by the Molasses Laboratory and the Superintendent of Grounds.

The establishment by the Experiment Station of an efficient inspection of airplanes on Midway Islands was completed in November 1936. This inspection

Fig. 10. Dr. Harold L. Lyon, Director, 1936–

service constituted an effective barrier through which oriental insects could not pass to spread human or plant diseases in Hawaii or the mainland. The establishment of this inspection service and its efficient operation were made possible by the material assistance and whole-hearted support of Pan American Airways. F. C. Hadden was placed in charge of the Midway station.

The Research Laboratories were increased in 1938 by the addition of the Sunlight Laboratory with H. W. Brodie, Research Associate, in charge, and Nitrogen Studies with D. A. Cooke, Research Associate, in charge. The title of the "Weather and Cane Growth Studies" project was changed to "Biochemistry Laboratory" and included studies on the ti plant in addition to the original studies on cane growth.

Again by 1939 war clouds were gathering over Europe with their many conflicting economic cross-currents inevitably affecting Hawaii's sugar industry. Sugar prices were excessively low, dropping to 2.75 cents early in the year. On September 3, war was declared in Europe and the first reaction as far as the price of sugar was concerned was an abrupt increase in price. This relief to the sugar industry proved to be short-lived as the President issued a proclamation on September 11, temporarily suspending the sugar quotas and, consequently, the price of sugar sank back again toward its old level. The effect of the quota suspension, specified by the President as being of a "temporary" character, was to put the sugar industry into the realms of conjecture in attempting to make long-range plans for the future. One immediate effect was a request for decreasing the cost of maintaining the Experiment Station which was met by the close cooperation and efforts of the staff, and without undue sacrifice of activities.

In the fall of 1939 airplane service was developed which connected Hawaii with New Zealand with stops at Canton Island and New Caledonia and, with the establishment of this new route, a new quarantine problem arose. This was solved in December 1939, with an inspection service at Canton, similar to that already in effect at Midway, with D. B. Langford in charge.

For guidance in the development of ground-water supplies, the plantations had for many years employed the services of W. O. Clark, Geologist, through an arrangement with the H.S.P.A., whereby Mr. Clark's expenses were partially met by stated charges for his services. In the Station budget for 1941 Mr. Clark's name was added to that of the other staff members and his services became available to the plantations under the same conditions as those of other members of the Station. Mr. Clark was listed as Geologist under the Special Research Laboratories. We list below the Station staff for December 1941:

EXPERIMENT STATION STAFF — 1941

H. L. Lyon, Director

ENTOMOLOGY
C. E. Pemberton, Executive Entomologist
R. C. L. Perkins, Consulting Entomologist
O. H. Swezey, Consulting Entomologist
F. X. Williams, Associate Entomologist
R. H. Van Zwaluwenburg, Associate Entomologist
F. A. Bianchi, Assistant Entomologist
J. S. Rosa, Laboratory Technician

PATHOLOGY
J. P. Martin, Pathologist
C. W. Carpenter, Associate Pathologist
D. M. Weller, Histologist

GENETICS
A. J. Mangelsdorf, Geneticist
C. G. Lennox, Associate Geneticist
William Brandt, Field Assistant
A. Doi, Field Assistant
R. Urata, Field Assistant

AGRICULTURE
R. J. Borden, Agriculturist
J. A. Verret, Consulting Agriculturist
R. E. Doty, Associate Agriculturist
L. R. Smith, Associate Agriculturist
H. A. Wadsworth, Irrigation Specialist
J. A. Swezey, Assistant-in-Irrigation
A. Y. Ching, Assistant in Cane Growth Studies

CHEMISTRY
F. E. Hance, Chemist
F. R. Van Brocklin, Associate Chemist
A. S. Ayres, Associate Chemist
Paul Gow, Assistant Chemist
K. W. McKenzie, Assistant Chemist
Q. H. Yuen, Assistant Chemist
T. Nishimura, Assistant Chemist
L. L. Sutherland, Clerk, Fertilizer Control

TECHNOLOGY
W. L. McCleery, Technologist
Raymond Elliott, Assistant Technologist
H. A. Cook, Assistant Technologist
Fred Hansson, Assistant Technologist
Morgan Kilby, Assistant Technologist
H. P. Kortschak, Assistant Technologist

BOTANY AND FORESTRY
H. L. Lyon, Botanist and Forester
E. L. Caum, Associate Botanist
L. W. Bryan, Associate Forester (Hawaii)
G. A. McEldowney, Associate Forester (Oahu)
A. W. Duvel, Associate Forester (Kauai)
Colin Potter, Nursery Superintendent

SPECIAL RESEARCH LABORATORIES
H. W. Brodie, Research Associate
W. O. Clark, Geologist
D. A. Cooke, Research Associate
Constance E. Hartt, Research Associate
A. R. Lamb, Research Associate
Howard Cooper, Research Assistant
A. H. Cornelison, Research Assistant
Ada Forbes, Research Assistant
Gordon Furmidge, Research Assistant
S. Moriguchi, Research Assistant
David Takahashi, Research Assistant
T. Tanimoto, Research Assistant
Richard D. Vroman, Research Assistant

ISLAND REPRESENTATIVES
F. C. Denison (Oahu)
O. H. Lyman (Hawaii)
D. S. Judd (Maui)
H. K. Stender (Kauai)

GENERAL
W. Twigg-Smith, Artist
A. R. Grammer, Office Manager
F. D. Kennedy, Bookkeeper
Mabel Fraser, Librarian
Martha Weber, Assistant Librarian
William Sa Ning, Superintendent of Grounds

It was, perhaps, the irony of fate that Hawaii, one of the most peaceful spots on the surface of the earth, should be the focal point for the induction of the United States into World War II. The calm waters of Pearl Harbor bordered in many places by fields of luxuriant sugar cane, became on December 7, 1941, a fiery cauldron of death and destruction. America was attacked! And all Americans can be proud of the manner in which Hawaii withstood the initial shock of the war — calm and confident in the belief of ultimate victory by our military forces and a willingness to cooperate to the utmost extent. The spirit of cooperation that has always keynoted the policies of the Hawaiian sugar industry can best be exemplified by a resolution offered to, and adopted by, the Trustees at the shortest annual meeting ever held by the H.S.P.A. at 10:00 A.M. on Monday, December 8, 1941 —"Be it resolved, that in light of the existing emergency, The Hawaiian Sugar Planters' Association does pledge its fullest cooperation to the Government of the United States and places all its facilities, services and membership at the disposal of our Government." Shortly thereafter the members of the Station staff, through the Director, extended their services to the Military Governor for such demands as he might have to make. It is a source of gratification to the staff that its services were requested in many instances, chiefly for consultation work on technical subjects in many and diverse fields of activity.

Even before the start of the war, the shortage of labor at the Station was beginning to be felt. Eight members of the staff had been called to active duty with the U. S. Army and numerous assistants, laboratory helpers and laborers left our employ for more lucrative work elsewhere and the Station was unable to replace them. This shortage of labor to a considerable extent was compensated for by increased services rendered by the remaining members but nevertheless the program of work had to be modified in many ways.

The onset of war forced the Station to suspend immediately work on some of its important projects and, at the same time created obligations and restrictions which greatly hampered work on all of its other projects. Numerous members of the Station joined the Armed Forces, while other members left to devote their skill to some special phase of the war effort. The serious depletion of the staff compelled each member who remained to work to the very limit of his or her ability to keep the Station's most important projects going. Ten members of the staff served in the B.M.T.C., two in the Territorial Guard, and two as special police officers, while most of the remaining members worked off

hours in medical units and other civilian organizations contributing to the war effort.

Among items of interest occurring during the period 1942-45 we note the following: All airplane inspection work on Midway and Canton was immediately suspended following the outbreak of war and the Station's inspectors were withdrawn. Additional work in plant physiology was inaugurated in 1942 by Dr. H.F. Clements as part of the Special Research Laboratories program. In order to compensate for the loss of personal contacts, caused by the suspension of the annual meetings of the Association and of the Technologists, a group of key personnel from the Station under the leadership of Dr. Lyon held conferences on the four sugar-producing islands during the fall months. This policy was repeated in 1944. On April 2, 1945, the Station held open house in commemoration of its 50th Anniversary. The interest shown by the community in this event and the publicity given by the press were very gratifying.

No history of the Station would be complete without recording its activities in forwarding the war effort. The entire Station contributed its efforts during the short period immediately following Pearl Harbor, when the Honolulu Blood Bank was frantically calling for blood and more blood. The Station not only made its laboratory facilities and apparatus available to the Blood Bank but assigned numerous members of its technical staff to full-time work.

Members of the Chemistry department devoted considerable time and effort to war work, mainly concerned with such matters as chemical surveys, camouflage problems, weed control, soil sterilization, chemical-dipping problems, precautions in handling toxic materials, demolition issues, and gas decontamination problems. In view of the confidential nature of many of these issues they cannot be discussed here. Two decontamination units for the treatment of humans contaminated with poisonous gases were erected on the Station grounds. These were the first decontamination units in the Territory to be made available for the treatment of civilian casualties and they served as models for the units which were later erected by the Office of Civilian Defense. Dr. Hance assumed a leading role in developing corrective measures to be employed in treating poison gas casualties and, in the units at the Station, trained men and women who later supervised the gas decontamination stations throughout the Islands. Eventually Dr. Hance's services were commandeered by the O.C.D. and for several months he spent a large part of his time each day at the O.C.D. headquarters in charge of the gas decontamination branch of that organization.

To meet a very obvious need, the Pathology department cultured the penicillin-yielding mold, *Penicillium notatum*, and produced in large quantities products of the highest quality and potency which were made available to local physicians throughout the long and critical period during which penicillin was not available for the treatment of civilians. The Station was the first institution in the Territory to prepare penicillin solutions and surgical dressings for topical application and immediately extended this service to the plantation hospitals and others interested. Instructions in the preparation of penicillin solutions and gauze dressings were given to military personnel and were reported to have been used with marked success. In some instances these materials were prepared aboard naval vessels on their way to the west Pacific and used successfully on evacuated wounded. The Navy eventually set up a "Penicillin Laboratory" at

Aiea where penicillin materials were prepared on a large scale and sent to forward areas by air transport.

Despite the fact that the work of the entomological inspectors at Midway and Canton was discontinued after December 7, 1941, the Entomology department continued to be actively engaged in airplane quarantine work through cooperation with the Army and Navy authorities. Military personnel was instructed in methods of finding and collecting insects from planes arriving in Hawaii and these were brought to the Station for identification. Army, Navy and Public Health authorities were regularly informed of the detailed identifications of the insects taken from planes. A series of lectures by the Station's entomologists were given to sanitary units of the Army, and advice and training were given to facilitate army surveys in mosquito identification and detection of breeding places. A large chart was prepared depicting in natural colors a number of the most dangerous types of insects which might reach Hawaii in airplanes. This was reproduced and distributed by the Territorial Board of Agriculture and Forestry to Army and Navy authorities for the information of all officers and men operating planes in the Pacific area. A survey of the insects of lowland Oahu was inaugurated by the Navy in cooperation with the Entomology department. Light traps of conventional design were set up in strategic locations and the large number of insects that were caught in these traps were brought to the Station for identification. Later the Army and U. S. Public Health Service utilized light traps for insect surveys, and again the Station's entomologists cooperated with the identification of the enormous numbers of insects that were accumulated in the traps. During the war years it was almost a daily experience to have personnel of medical units of the armed forces call on the entomologists for instruction or information on matters pertaining to medical entomology within the Pacific area. Insects were very frequently submitted for identification because of their suspected bearing on human health. These came not only from localities within Hawaii but also from various other Pacific islands. Fortunately the entomologists were usually in a position to supply, without delay, the information or instruction desired, due largely to the Station's extensive reference collection of insects, and particularly to the valuable entomological library that the Station possesses.

One of the most active units of the Station during the war was the Library. It was practically a war-time utility and scarcely a day passed that a group of service men could not be found around the Library tables. Information was requested on an amazing and endless variety of subjects such as chemistry, ordnance, agricultural crops, rat control, mosquito data and other material pertinent to camp or field work, diversified and soilless agriculture, insects, botany, and so on. The map collection showing sections of the Pacific in which the war was being fought proved of special interest as well as the files of clippings and photographs of Pacific points. Mechanical handbooks were loaned to naval officers to use while at sea and to skilled workmen in Pearl Harbor shops. Public Health personnel were accommodated during the rat clean-up campaign and the dengue fever epidemic. It was indeed a source of great satisfaction that the Station's Library could and did supply such a varied demand for information.

Considerable attention was given to diversified agriculture by the Station during this period. The Genetics, Agriculture, Entomology, and Pathology

departments were particularly active in this phase of food production, not only in testing many new varieties of vegetables and other food plants, but in their fertilization, and protection from insects and diseases. Inspections were made upon request of home gardens in the vicinity of Honolulu and advice given on fertilizing, spraying, etc.

The primary object of the Molasses laboratory had been to produce a high-quality yeast for human consumption. After December 7, however, the shortage of bakers' yeast in Honolulu brought many requests to the Station for aid. It was found that the yeast slurry was excellent for bread making and for a period of six months the Station furnished yeast slurry to numerous bakeries. One U. S. Army bakery conducted extensive experiments with the Station's slurry and reported excellent results.

In cooperation with the Mortuary Committee of the O.C.D., the necessary equipment was segregated at the Experiment Station and appropriate arrangements made so that the Station's facilities could be immediately converted into a mortuary and identification station should the occasion demand. We can be very grateful that this was one phase of cooperation that was not needed in the course of events.

The Station's service flag carries twenty-one blue stars and one gold one. The following men are represented on the flag:

A. R. Lamb	C. A. Wismer
L. W. Bryan	Tatsuo Tanoura
A. W. Duvel	G. B. Stewart
Howard Cooper	R. H. Ward
Richard Duncan	M. M. Kilby
T. Morikawa	T. Nishimura
J. A. Johnson, Jr.	E. S. Yamamoto
D. T. Takahashi	K. Iseki
J. N. Warner	T. E. Onaka
Q. H. Yuen	T. Matsuyama
D. S. Judd	E. Watanabe

The gold star honors the memory of Major John A. Johnson, who was killed in action in Italy.

Fifty years have passed since that memorable day when Dr. Walter Maxwell landed from the steamship *China* and set up his office and laboratory on Nuuanu Street. Today, after fifty years of service with the sugar industry of the Hawaiian Islands, we find that the Experiment Station has grown into a large institution, but is still devoted primarily to the application of science to the growing and processing of sugar cane. Its headquarters are at 1527 Keeaumoku Street and its many administrative buildings, laboratories, and greenhouses are compactly set on 8.821 acres of land, including the original area leased in 1896. The policies and administration of the Station are carried out, as they have been for many years, through the Trustees of the H.S.P.A., the Experiment Station Committee, and the Director. There are seven principal departments — Agriculture, Chemistry, Entomology, Pathology, Sugar Technology, Genetics, and Botany and Forestry each with its department head and capably staffed with associates, assistants and helpers. In addition there are the Special Research Laboratories which include units for special study on Geology, Irrigation, Weather, Enzymes, Plant Physiology, Cane Growth, Ti investigations, Yeast, and Levulose. These

units are mostly small and are headed by an Associate in Research who reports directly to the Director. Other minor departments, mostly administrative or service, are the Illustration department, Business Office, Library, and Makiki Buildings and Grounds.

The Library is a particularly good example of the growth of the Experiment Station. Founded in 1907 by Mr. Kirkaldy "with the help of a boy assistant," it contained at that time 1,250 bound volumes and a collection of serials and pamphlets. On September 30, 1945, the Library had 25,257 accessed volumes, thousands of pamphlets of great scientific value, and a "Project File" of around 1,500 folders filed by subjects, and containing clippings, reprints, and all reports submitted by the staff on the subject of sugar cane, its culture and manufacture.

In addition to the area occupied by the main laboratories and administrative buildings at 1527 Keeaumoku Street, the Experiment Station has under its jurisdiction the following areas on the Island of Oahu: A large leased area at Waipio divided about equally between the experimental field projects of the Agricultural department and the cane-breeding activities of the Genetics department; the Helemano Variety Station at the uppermost limits of the cane-growing region on Oahu, the Ewa Variety Station on the lowland, saline soils, the Kailua Substation on the windward side of Oahu and used mostly by the Genetics department for cane variety work; the Pathology Plots at Alexander and Bingham Streets not far from the main Station and utilized by the Pathology Department; and the Manoa Arboretum near the head of Manoa Valley and devoted almost entirely to the interests of the Botany and Forestry department. The Waipio Substation and the two variety stations, Helemano and Ewa, are under the supervision of the Island Representative for Oahu.

On the Island of Hawaii there are four cane variety units under the direction of the Island Representative for Hawaii. These are: the Hilo Variety Station, the Hamakua Variety Station, the Kohala Variety Station, and the Hawaii Seed Nursery. At the Olaa Sugar Company there is a joint project on Leaf Scald disease between the plantation and the Pathology department.

Kauai has the Kauai Variety Station at Lihue which is under the supervision of the Island Representative for Kauai.

The Maui substation is situated on the Hawaiian Commercial and Sugar Company's cane lands, and it is supervised by the Maui Island Representative.

The area on Molokai is utilized mostly for sugar-cane quarantine facilities although some diversified agriculture projects are under way.

The Experiment Station staff at the close of 1945 was composed of the following personnel:

EXPERIMENT STATION STAFF — 1945

H. L. Lyon, Director

H. A. Alexander, Assistant-in-Training
A. S. Ayres, Associate Chemist
F. A. Bianchi, Assistant Entomologist
R. J. Borden, Agriculturist
R. Boyen, in Charge of R. C. M.
W. S. K. Brandt, Island Representative (Maui)
H. W. Brodie, Research Associate
L. W. Bryan, Associate Forester (Hawaii)

C. W. Carpenter, Associate Pathologist
E. L. Caum, Associate Botanist
R. M. Chalmers, Assistant-in-Training
A. Y. Ching, Field Assistant
W. O. Clark, Geologist
H. A. Cook, Associate Technologist
D. A. Cooke, Research Associate
A. H. Cornelison, Research Assistant
Jean L. Dabagh, Assistant Librarian
F. C. Denison, Island Representative (Oahu)
A. Doi, Assistant Geneticist
M. Doi, Analyst
R. E. Doty, Associate Agriculturist
A. W. Duvel, Associate Forester (Kauai)
Ada Forbes, Research Assistant
Mabel Fraser, Librarian
Paul Gow, Associate Chemist
A. R. Grammer, Office Manager
H. Hagihara, Analyst
R. K. Hamilton, Assistant Technologist
F. E. Hance, Chemist
Constance E. Hartt, Research Associate
M. Isobe, Research Assistant
H. S. Iwata, Laboratory Technician
D. S. Judd, Island Representative (Kauai)
F. D. Kennedy, Bookkeeper
Morgan Kilby, Assistant Technologist
P. B. Kim, Assistant Chemist
H. Koike, Laboratory Technician
H. P. Kortschak, Associate Technologist
A. R. Lamb, Research Associate
H. M. Lee, Laboratory Technician
J. R. Lowrie, Research Associate
O. H. Lyman, Island Representative (Hawaii)
H. L. Lyon, Botanist and Forester
R. W. MacQueen, Assistant-in-Training
A. J. Mangelsdorf, Geneticist
J. P. Martin, Pathologist
H. P. Mau, Analyst
W. L. McCleery, Technologist
G. A. McEldowney, Associate Forester (Oahu)
B. K. Nishimoto, Field Assistant
C. E. Pemberton, Executive Entomologist
R. C. L. Perkins, Consulting Entomologist
Colin Potter, Nursery Superintendent
L. J. Rhodes, Assistant Technologist
J. S. Rosa, Laboratory Technician
William Sa Ning, Superintendent of Grounds
H. K. Stender, Research Associate
O. H. Swezey, Consulting Entomologist
David Takahashi, Research Assistant
T. Tanimoto, Research Assistant
R. Urata, Assistant Geneticist
G. Uyehara, Analyst
F. R. Van Brocklin, Associate Chemist
R. H. Van Zwaluwenburg, Associate Entomologist
J. A. Verret, Consulting Agriculturist

H. A. WADSWORTH, Collaborator in Irrigation
J. N. WARNER, Assistant Geneticist
D. M. WELLER, Histologist
F. X. WILLIAMS, Associate Entomologist
C. A. WISMER, Assistant Pathologist
J. YAMAMOTO, Assistant Artist
Y. YAMASAKI, Field Assistant
Q. H. YUEN, Assistant Chemist
E. C. ZIMMERMAN, Systematic Entomologist

It is a far cry from the 149,627-ton crop of sugar produced in 1895 from 46,399 acres to the over a million-ton crop of 1932 (1,025,354) produced from 139,470 acres. Production since 1932 has been lower, first on account of enforced crop restrictions imposed by Government quotas, and later because of labor shortage during the war years. Undoubtedly the increase in acreage yields may be attributed to a number of factors, such as improved varieties of cane, increased knowledge of fertilization, more thorough preparation and cultivation of the soil, the harvesting of crops during shorter periods, thereby obtaining maximum and continuous growth, a greater control of pests and diseases, decreased manufacturing losses, in fact, to put it broadly, the intensive application of science to each and every branch of our industry.

Research work is never ended, for it is only too true that the more one learns, the more one realizes the extent of his ignorance. In spite of the progress made in the past fifty years, there is a vast field of experimental exploration open to the Experiment Station. There are many questions regarding fertilization, irrigation and cultivation that remain to be answered satisfactorily. The various factors which determine the quality of cane are a matter of continuous research. The amazing amount of definite knowledge regarding the fundamental principles of heredity merely serves to disclose the vast amount of unknown territory in this branch of science, and despite the unquestioned greater yielding ability of our newer cane varieties, we must quest for still better ones. Chemical weed control with the shortage of labor and the growing tendency for more and more mechanical operations in the field, is of utmost importance to the sugar-cane planter and presents a problem that will require careful research. The arrival in the Territory of dozens of new insect species during the war years has put to the entomologists the problem of their economic effect on the sugar industry and their control, if proved to be injurious to sugar cane. Quarantine must be maintained, but even with the strictest of quarantine regulations, we must test our commercial canes against foreign diseases in order to be prepared for emergencies. Mill operations, now greatly complicated by mechanical harvesting, present a vast field for the research worker to exercise his skill and ingenuity.

We cannot predict the course of future events but can be assured that the efficiency of the Hawaiian sugar industry will be put to the test. It will present a challenge that must be met and this is an appropriate time for an intensive study of our sugar industry to the end that research be planned to attack those problems, the solutions of which may be expected to lower costs or increase production per dollar spent. And while we are seeking the solutions of the problems of the hour, let us not forget the need and value of basic research projects, those patient, careful, inquisitive drives for information, intelligently planned, skilfully executed, where the scientists who formulate their successive

Fig. 11. Experiment Station staff on the occasion of its Fiftieth Anniversary on April 2, 1945.

steps are closely aligned with their execution, performing much of the work personally, and ever on the alert for the little developments in a smooth procedure that properly interpreted may mean discovery. Such work is pure research, and it is research of this type alone that will satisfactorily fathom the perplexing interrelationships between the sugar-cane plant and its environment, and place before us facts that can be used with profit for all time. Therefore, let us arrange to give research the place it deserves in our program of work — a place so much apart from the immediate demands of the hour as to brook no interference from them.

CHRONOLOGICAL SUMMARY

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
MARCH 16, 1947, TO SEPTEMBER 15, 1947

Date	Per pound	Per ton
March 16, 1947 — March 29, 1947	6.125¢	$122.50
March 30, 1947 — August 5, 1947	6.185	123.70
August 6, 1947 — September 15, 1947	6.32	126.40

THE HAWAIIAN PLANTERS' RECORD

EXPERIMENT STATION STAFF

H. L. LYON, Director

B. B. ALEXANDER, Assistant-In-Training
H. A. ALEXANDER, Acting Island Rep. (Maui)
F. M. ASHTON, Assistant Biochemist
A. S. AYRES, Associate Chemist
F. A. BIANCHI, Assistant Entomologist
J. D. BOND, Coordinator of Training
R. J. BORDEN, Agriculturist
R. BOYEN, In Charge of R.C.M.
W. R. BRADLEY, Assistant-In-Training
H. W. BRODIE, Climatologist
L. W. BRYAN, Associate Forester (Hawaii)
G. O. BURR, Physiologist & Biochemist
R. E. CARROLL, Assistant-In-Training
E. L. CAUM, Associate Botanist
A. Y. CHING, Agricultural Assistant
H. A. COOK, Associate Technologist
A. H. CORNELISON, Associate Climatologist
D. C. COX, Geologist
JEAN L. DABAGH, Assistant Librarian
F. C. DENISON, Island Representative (Oahu)
A. DOI, Assistant Geneticist
M. DOI, Assistant Chemist
R. E. DOTY, Associate Agriculturist
A. W. DUVEL, Associate Forester (Kauai)
T. B. ELDER, Assistant-In-Training
ADA FORBES, Assistant Physiologist
MABEL FRASER, Librarian
PAUL GOW, Associate Chemist
A. R. GRAMMER, Office Manager
H. HAGIHARA, Analyst
R. K. HAMILTON, Assistant Technologist
F. E. HANCE, Chemist
CONSTANCE E. HARTT, Associate Physiologist
T. HAYASHI, Laboratory Technician
M. ISOBE, Assistant Physiologist
H. S. IWATA, Laboratory Technician
D. S. JUDD, Island Representative (Kauai)
F. D. KENNEDY, Bookkeeper
MORGAN KILBY, Assistant Technologist
P. B. KIM, Assistant Chemist
H. KOIKE, Laboratory Technician
H. P. KORTSCHAK, Associate Technologist
A. R. LAMB, Associate Biochemist
H. M. LEE, R. C. M. Technician
O. H. LYMAN, Island Representative (Hawaii)
H. L. LYON, Botanist and Forester
A. J. MANGELSDORF, Geneticist
J. P. MARTIN, Pathologist
H. P. MAU, Analyst
W. L. MCCLEERY, Technologist
G. A. MCELDOWNEY, Associate Forester (Oahu)
J. B. MENARDI, Supt. Samoa Substation
R. C. MILLER, Assistant Chemist
J. F. MORGAN, JR., Assistant-In-Training
B. K. NISHIMOTO, Field Overseer
C. E. PEMBERTON, Executive Entomologist
R. C. L. PERKINS, Consulting Entomologist
COLIN POTTER, Nursery Superintendent
L. J. RHODES, Assistant Technologist
J. S. ROSA, Laboratory Technician
WILLIAM SA NING, Superintendent of Grounds
R. SPELLMAN, Assistant Technician
H. K. STENDER, Associate Coordinator
F. STOKES, Assistant Technician
O. H. SWEZEY, Consulting Entomologist
DAVID TAKAHASHI, Assistant Biochemist
T. TANIMOTO, Assistant Biochemist
J. W. TAYLOR, Assistant-In-Training
S. M. TUTTON, Assistant-In-Training
R. URATA, Assistant Geneticist
G. UYEHARA, Analyst
F. R. VAN BROCKLIN, Associate Chemist
R. H. VAN ZWALUWENBURG, Associate Entomologist
J. A. VERRET, Consulting Agriculturist
H. A. WADSWORTH, Collaborator in Irrigation
J. N. WARNER, Assistant Geneticist
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